FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS

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I hereby declare that the thesis entitled "**FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS**" submitted towards partial fulfillment of the requirements for the award of **MS in Orthopedics** degree to BFUHS is a compilation of original work carried out by me under the supervision of **Dr. Deepak Jain**, Professor, Department of Orthopedics and **Dr. Harpal Singh Selhi,** Professor, Department of Orthopedics. No part of this thesis has formed the basis for the award of any degree previously.

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Dedicated

to

my Family,

friends

&

Teachers

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ABBREVIATIONS

AO/OTA	Orthopaedic trauma association
CT	Computed tomography
CCS	Cancellous cannulated screws
CR	Closed reduction
DF	Domestic fall
DF	Dorsiflexion
ORIF	Open reduction and internal Fixation
PM	posterior malleolus
PF	Plantar flexion
PER	Pronation external rotation
RTA	Road traffic accident
SER	supination external rotation

ABSTRACT

Introduction: Ankle fractures involving fractures are quite prevalent in both elderly and young patients. These fractures can be managed with a variety of treatment options ranging from conservative management to open reduction and internal fixation. Due to frequent injury to ligaments of ankle, posterior malleolar fragment size and various other anatomic considerations, no treatment modality gives good results in all patients. This study aims to evaluate union time, functional outcome of ankle fractures associated with fracture of posterior malleolus.

Material and Methods: From November 2019 to august 2021, 18 patients of posterior malleolus fracture treated with different methods in our hospital were included in this study and were prospectively followed up for a period of 6 months. Functional outcome was measured with using "AOFAS "SCORE (American Orthopaedic Foot And Ankle Society)"

Results: Out of 18, 17 patients were available for follow up and final analysis.11 patients had SER type of injury, 6 patients had PER type of injury as per lauge Hansen Classification. According to AO/OTA classification, 11 patients had Type 44B fracture, 6 had Type 44C fracture. Average age of group was 52 years with average follow up of 15.4 months, 14 out of 17 patients having injury after RTA with average time to union of 10.12 weeks. 13 out of 17 patients had good to excellent AOFAS score with an average score of 81.65. Most common complication was post traumatic arthritis around ankle joint

Conclusions: It is critical to have anatomical reduction of PM fragment regardless of size of the fragment as well as method employed to obtain the reduction – whether indirect by reduction of lateral malleolus or by direct exposure and fixation of PM fragment in order to get satisfactory results. We conclude that ankle fractures with a Posterior malleolar fragment are complex, high energy injuries which often necessitates surgical fixation and the appropriate treatment depends on various factors.

Keywords: posterior malleolus fragment, AOFAS score, lauge Hansen, AO/OTA

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INTRODUCTION

The fractures of posterior malleolus are defined as fracture of the posterior edge of the distal tibia.[1-2] Ankle fractures are common often require surgery, and represent about one –tenth of all fractures.[3] Overall about 2/3rd of ankle fractures are isolated malleolar fractures, 1/4 are bimalleolar, the remaining 7 precent are trimalleolar. isolated posterior malleolus fractures are rare , with an estimated incidence of about 0.5 to 1 percent of all the fractures[4]. Traditionally, the presence of posterior malleolar fragment has been associated with a less favourable prognosis in ankle fractures.[5-6]

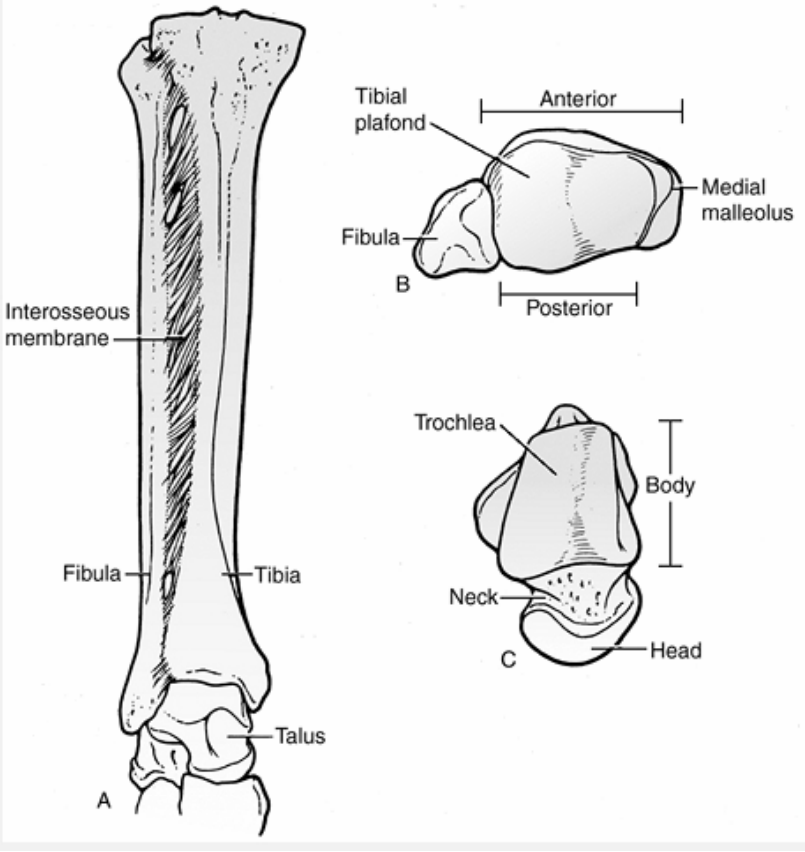
It is speculated that failure to adequately recognize and treat posterior malleolar fractures in the past has contributed to less than optimal treatment results after ankle fractures. [7] Despite an increasing body of literature. The best treatment of posterior malleolar fractures is still subjected to debate[8-9] for several decades , criteria for surgical fixation of a posterior malleolar fragment were fragment size of 1/4 to 1/3 of articular surface and displacement of more than 2mm on the lateral radiographs.[10-11] recently, goals of operative fixation has been reformulated as follows; (1) restoration of articular congruity at the distal tibia and posterior containment of talus (2) bone to bone fixation of the posterior tibiofibular ligament (3) restoration of fibular notch thus facilitating reduction of the distal fibula[12]therefore an understanding of the posterior malleolus anatomy , the ligamentous attachments , and its contribution to ankle congruity and stability is critical in determining the appropriate treatment.[13]

These fractures can occur in young age group following high energy trauma and in older patients after a low energy fall. It is common in females above 65 years of age after a trivial fall. Overall male to female ratio of ankle fractures has been reported to be 1:1 in population[14]

The ankle joint is a complex, 3 bone joint consisting of tibial plafond, the distal fibula and the talus. The ankle joint is saddle shaped, and derives its

stability from a combination of bony and ligamentous structures .the significant role of medial and lateral ligament complexes in ankle congruity and stabilization is well described.[15]

Ankle joint is a complex three bone joint. The ankle joint is a mortise in which the talus is constrained by the fibula laterally and the tibia both superiorly and medially. This configuration has also been referred to as the malleolar fork. The distal aspect of the tibia flares and is quadrilateral in cross section, terminating in an articular surface5.[16]



Picture 1: Bony anatomy of the ankle. Mortise view (A), inferior superior view of the tibiofibular side of the joint (B), and superior inferior view of the talus (C). [17]

Articulating surfaces:

Articular surfaces are covered by hyaline cartilage. The talar articular surface for the medial malleolus is a proximal area on the medial talar surface, and is fairly flat, comma- shaped and deeper anteriorly. [17] The

larger lateral talar articular surface is triangular and vertically concave, while the articular surface on the lateral malleolus is reciprocally curved. Posteriorly, the edge between the trochlear and fibular articular surfaces of the talus is believed to a narrow, flat triangular area that articulates with the inferior transverse tibiofibular ligament [17]

MECHANISM OF INJURY

The ankle functions in combination with the other joint segments of the lower limb to move the center of mass of the body as effectively as possible with a minimum expenditure of energy.

In normal walking, the ankle is in plantar flexion, as the heel contacts the ground and the weight of the body is accepted by the foot. During stance phase, the ankle initialy dorsiflexes as the body moves forward over the foot, and then plantar flexes as the foot pushes off. The ankle then dorsiflexes again to help clear the foot during swing phase. Motion analysis studies have shown that a minimum of 10 degree of dorsiflexion and 20 degree of plantar flexion are needed for this ankle function during walking. [18]

The malleoli acts as pillors for attachment of the ligaments close to the axis of rotation of the joint. This enables some portion of the medial and lateral ligament complex to remain tight through out the arc of flexion and extension and there by provides rotational stability.

The stability of the ankle is primarily dependent on four groups of bony and ligamentous structure. 1) The medial malleolus and medial collateral ligaments, 2) Lateral malleolus and lateral collateral ligaments, 3) Anterior syndesmotic ligaments and their bony attachment sites on the tibia and fibula. 4) Posterior syndesmotic ligaments and posterior malleolus. If only one of the above group is injured stability will be maintained. As each successive groups of structures are injured, the ankle becomes more unstable.

The weight bearing contact area of the ankle is relatively large compared with the hip or knee, owing to the high congruence of the articular surface.

Displacement of the talus leads to incongruence, which decreases the contact surface area and increases the stresses over the remaining contact areas. Ramsey and Hamilton reported that a 1mm lateral shift of the talus decreased the contact area by 42%; with 3mm of lateral shift the contact area decreased by more than 60%. The fibula is essential is providing stability and preventing displacement of the talus to shift or tilt even if the medial ligaments are intact.

The pattern of injury depends upon many factors including the age of the patient, the quality of the bone, the position of the foot at the time of injury and the direction, magnitude and rate of the loading forces.

The current understanding of the mechanism of ankle injury is derived from the work of Lauge Hansen. He emphasized the influence that the position of the foot had on the injury pattern and correlated the position with the direction of the deforming forces.

The position of the foot at the time of injury is described first and the direction of deforming force is described second. The common deforming forces acting on the ankle are adduction, abduction, external rotation and vertical loading. Pronation and supination refer to the position of the foot as it rotates around the axis of the subtalar joint. Adduction and abduction are deforming forces while internal and external rotation are rotational movements around the vertical axis of the tibia.[18]

Supination adduction :

As the foot supinates the lateral structures tighten, continued supination and adduction force may rupture portion of lateral collateral ligaments or avulse these ligaments from their bony attachment sites on distal fibula, resulting in a transverse fracture below the level of syndesmosis. Further adduction drives the talus against the medial side of the joint, resulting in vertical fracture of the medial malleolus and some times an impaction fracture of the medial articular surface of the tibia.

Supination external rotation:

As the supinated foot externally rotates, the lateral structures and anterior

syndesmotic ligaments tighten, with resulting rupture or avulsion of its bony insertion. External rotation produces a spiral fracture of fibula which runs anteroinferior or posterosuperior. If the fracture begins below the anterior tubercle of the fibula, the anterior tibiofibular ligaments remains intact. The fracture passes obliquely through the superior articular surface of the fibula.

Pronation abduction :

In pronation the medial structures tighten and are injured first, there is either an avulsion fracture of the medial malleolus or rupture of the deltoid ligament. The abduction force then either ruptures the syndesmotic ligaments or avulse their bony attachment sites.

Pronation external rotation :

The medial side is injured first. External rotation then results in rupture of the anterior tibiofibular ligament or its bony insertion, followed by fracture of the fibula at or above the syndesmosis. The fibular fracture is spiral, but runs anterosuperior to posteroinferior[18]

CLASSIFICATIONS

1. LAUGE HANSEN CLASSIFICATION

1. Supination Adduction (SA):
    - o Transverse avulsion type fracture of the fibula below the level of the joint, or tear of the lateral collateralligaments.
    - o Vertical fracture of medialmalleolus.
2. Supination External rotation (SER);
    - o Disruption of the anterior tibiofibularligament.
    - o Spiral oblique fracture of the distal fibula
    - o Disruption of the posterior tibiofibular ligament or rupture of the posterior malleolus.
    - o Fracture of the medial malleolus or rupture of the deltoid ligament.

3. Pronation Abduction (PA):
    - Transverse fracture of the medial malleolus or rupture of the deltoidligament.
    - Rupture of the syndesmotic ligaments or avulsion fracture of theirinsertions.
    - Short, oblique fracture of fibula above the level of joint.
4. Pronation External rotation(PER)
    - Transverse fracture of the medial malleolus or disruption of the deltoid ligament
    - Disruption of the anterior tibiofibularligament.
    - Short oblique fracture of the fibula above the level of thejoint.

2) DANIS WEBERCLASSIFICATION:

This system is based on the level of the fracture of the fibula. The more proximal the fracture of the fibula, the greater the risk of injury to the syndesmosis and the more likely that the joint will be unstable.

Type- A:

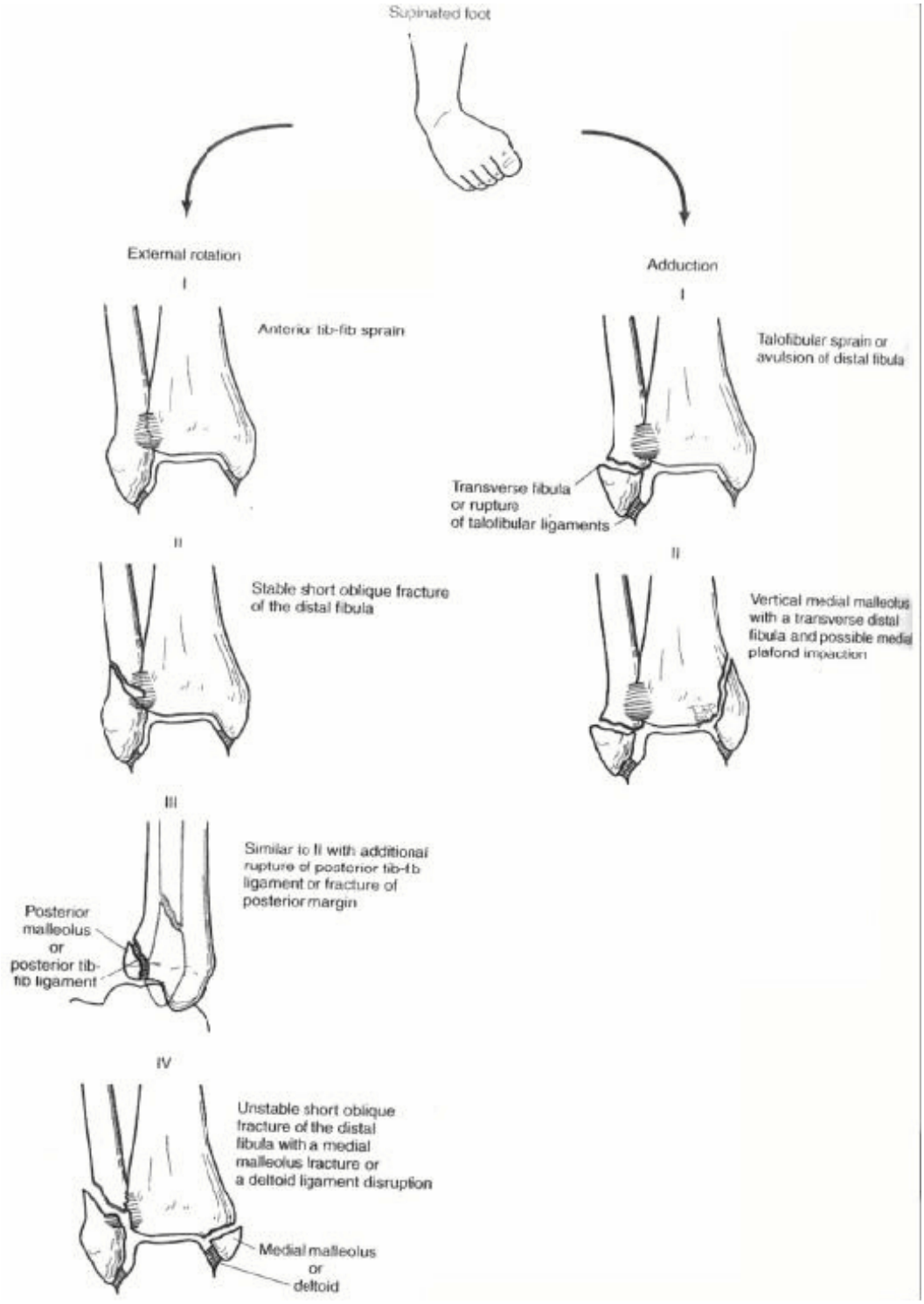
- Fracture of the fibula occuring below the level of tibial plafond.
- Oblique or vertical fracture of the medial malleolus.
- Corresponds to Lauge Hansen's supination adduction injury.

Type- B:

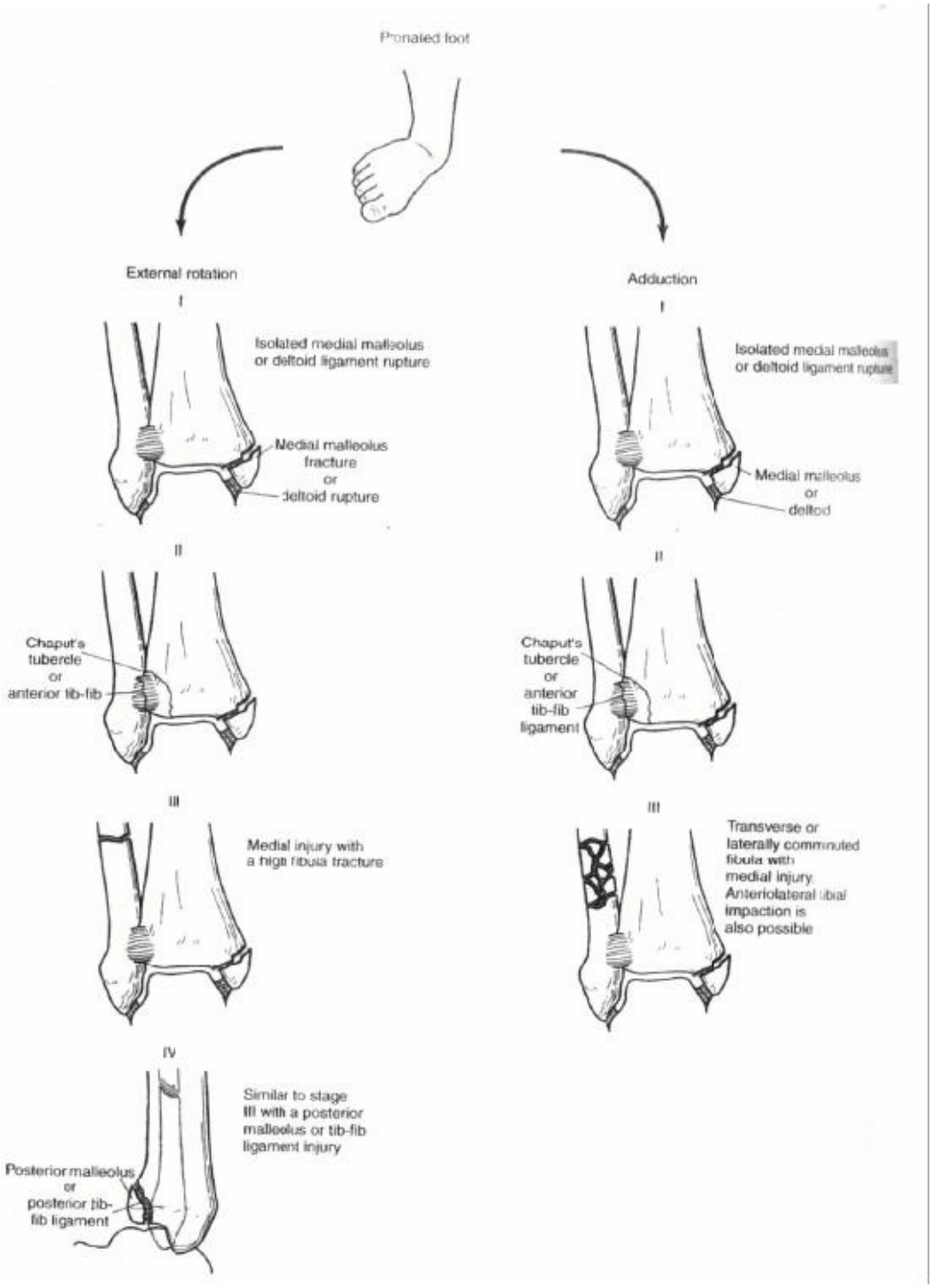
- Oblique or spiral fracture at or near the level of syndesmosis - caused by external rotation.
- Corresponds to supination – external rotation injury of LaugeHansen.

Type- C:

- There is fracture of fibula above thesyndesmosis.
- Corresponds to pronation-eversion or pronation abduction stage 3 injuries of Lauge Hansen.


Supinated foot
External rotation
I
Anterior tib-fib sprain
II
Stable short oblique fracture of the distal fibula
III
Similar to II with additional rupture of posterior tib-fb ligament or fracture of posterior margin
Posterior malleolus or posterior tib-fib ligament
IV
Unstable short oblique fracture of the distal fibula with a medial malleolus fracture or a deltoid ligament disruption
Medial malleolus or deltoid
Adduction
I
Talofibular sprain or avulsion of distal fibula
Transverse fibula or rupture of talofibular ligaments
II
Vertical medial malleolus with a transverse distal fibula and possible medial plafond impaction

Picture 2: Schematic diagram and case examples of Lauge -Hansen supination- external rotation and supination adduction ankle fractures[18]


Pronated foot
External rotation
Adduction
I
Isolated medial malleolus or deltoid ligament rupture
Medial malleolus fracture or deltoid rupture
Isolated medial malleolus or deltoid ligament rupture
Medial malleolus or deltoid
II
Chaput's tubercle or anterior tib-fib
Chaput's tubercle or anterior tib-fib ligament
III
Medial injury with a high fibula fracture
Transverse or laterally comminuted fibula with medial injury. Anteriolateral tibial impaction is also possible
IV
Similar to stage III with a posterior malleolus or tib-fib ligament injury
Posterior malleolus or posterior tib-fib ligament

Picture 3: Schematic diagram and case examples of Lauge-Hansen pronation- external rotation and pronation-abduction ankle fracture[18]

3) AO CLASSIFICATION:

AO Classification of fractures has further divided each of these three types into three groups - to quantify the spectrum of injury within each type.

Type- A: Fibula fracture below syndemosis (Infra-syndesmotic)

A1 -Isolated

A2 -With fracture of medial malleolus

A3 -With a posteromedial fracture.

Type- B: Fibula fracture at the level of syndesmosis (Trans-syndesmotic).

B1 -Isolated

B2 -With medial lesion (Malleolus orligament)

B3 -With a medial lesion and fracture of posterolateral tibia.

Type- C: Fibula fracture above syndesmosis (Supra-syndesmotic)

C1 -Diaphyseal fracture of the fibula, simple

C2 -Diaphyseal fracture of the fibula, complex

C3 -Proximal fracture of the fibula.

ANATOMIC AND BIOMECHANICAL ASPECTS

The distal tibia ends in a concave articular surface and serves to transmit axial compression forces.[19] . The medial part of posterior malleolus is seperated from medial malleolus by malleolar groove containing the posterior tibial tendon. The lateral half of posterior malleolus is formed by a marked bony prominence, the posterior tubercle of distal tibia that also forms the posterior part of the fibular notch. The posterior tubercle of the distal tibia also serves as the origin of strong superior, obliquely oriented fibres of trapezoidally shaped posterior tibiofibular ligament. Its inferior, more horizontally oriented fibres originate from the rim of the articular surface of the distal tibia, medial to the posterior tubercle. The superior and inferior fibres of the ligament converge distally toward the posterior fibula, where they insert at the circumference of the malleolar fossa.[20]

Factors maintaining stability:

Passive stability is conferred upon the ankle mainly by the medial

and lateral ligament complexes, the distal tibiofibular ligaments, the crossing and attached tendon tunnels, the bony contours and the capsular attachments. Dynamic stability is conferred by gravity, muscle action and ground reaction forces. Stability requires the continuous action of soleus, and increases (often involving gastronemius) with leaning forward, and vice versa .[21]

LIGAMENTS OF THE ANKLE JOINT:

Fibrous Capsule:

Around the joint, the fibrous capsule is thin in front and behind. It is attached proximally to the borders of the tibial and malleolar articular surfaces, and distally to the talus near the margins of its trochlear surface, except in front where it reaches the dorsum of the talar neck. The capsule is strengthened by strong collateral ligaments.

MEDIAL COLLATERAL LIGAMENT (Deltoid Ligament):

This is a large, strong triangular ligament spreading fan shaped over the medial part of the ankle joint, it originates in the medial malleolus and inserts on the navicular bone, talus and calcaneus [22]

It has two layers

1) Superficial layer consisting of
   a. Tibio-navicular ligament
   b. Tibio-calcaneal ligament
   c. Talo-tibial ligament
2) Deep layer consistingof
   a. Anterior tibiotalar ligament
   b. Posterior tibiotalar ligament.

LATERAL COLLATERAL LIGAMENTS:

It has got three separate bands of fibres attaching from lateal malleolus tip to talus and calcaneum.

1) Anterior talofibular ligament: It is a 5mm wide band situated in the anterolateral joint capsule. Its attachment is in the anterior aspect of the lateral malleolus and it proceeds almost horizontally forward and medially

to gain insertion on the lateral aspect of the talar neck.

2) **Calcaneofibular ligament:** It is an extracapsular, styloid ligament having a diameter of about 5mm and a length of 20- 25mm. It extends from the tip of lateral malleolus to the lateral surface of thecalcaneus.

3) **Posterior talofibular ligament:** It is a strong intracapsular ligament originating in the fossa of the lateral malleolus and spreads in the shape of a fan, its anterior short fibres inserting laterally on the posterior edge of the talus and its posterior long fibres medially on the lateral tubercle of the posterior process of thetalus.

The **inferior tibiofibular** joint is a syndesmosis joint (contains no articular cartilage) and has got the following ligaments.

1) **The anterior tibio fibular ligament:** It is a strong ligament, 20mm wide and 20- 30mm long, originating in the anterior tubercle of the tibia and anterolateral part of tibial epiphysis. Its fibres proceed in an oblique distal and lateral direction in order to insert anteromedially on the upper portion of the lateral malleolus.
2) **InterosseousLigament;** Its fibres originate in the greater part of the fibular notch and inserts at the same level on the anterior two thirds of the medial fibular surface.
3) **Posterior Tibio Fibular Ligaments**: It is a strong ligament which runs from the distal, lateral part of the tibial epiphysis in an oblique course distally and laterally to the insertion on the posterior surface of the lateral malleolus.[22]

BLOOD SUPPLY OF THE ANKLE :

The arteries crossing the ankle sends branches which form arterial anastamosis around the ankle, tarsus and metatarsus.

The anterior medial malleolar artery:

It starts about 5cm above the ankle, passing behind the tendons of extensor hallucis longus and tibialis anterior to the medial side of the joint, where it joins branches of the posterior tibial and medial plantar arteries.

The anterior lateral malleolar artery:

It passes behind the tendons of extensor digitorum longus and peroneus tertius to supply the lateral side of the ankle, anastamosing with the perforating branch of the peroneal and ascending twigs from the lateral tarsal artery.

The arteries around the ankle joint anastamose freely to form networks around and below the corresponding malleoli.

The medial malleolar network is formed by the anterior medial malleolar branch of the anterior tibial artery, the medial tarsal branches of the dorsalis pedis, the malleolar and calcaneal branches of the posterior tibial, and branches from medial plantar artery.

The lateral malleolar network is formed by the anterior lateral malleolar branch of the anterior tibial, the lateral tarsal branch of the dorsalis pedis, the perforating and the calcaneal branches of the peroneal, and twigs from the lateral plantar artery.

NERVE SUPPLY :

The talocrural joint is innervated by branches from the deep peroneal, saphenous, sural and tibial nerves (or medial and lateral plantar nerves, depending on the level of division of the tibial nerve). Occasionally, the superficial peroneal nerve also supplies the ankle joint.

MOVEMENTS OF THE ANKLE :

The movements of the ankle joint are hinge like which occurs about an axis through the body of talus.

Table 1: Normal Movements of Ankle Joint

Sl. No.	Movements	Range of Movements in degree	Muscle Acting	Nerve Supply
1	Dorsiflexion	0-30	Tibilias anterior External digtorium longus External hallucis longus Peroneus tertius	Deep peroneal nerve
2	Plantarflexion	0-50	Tibialis posterior Flexor hallucis longus Flexor digitorum longus	Tibial nerve
3	Inversion	0-35	Tibialis anterior Tibialis posterior	Deep peroneal nerve Tibial nerve
4	Eversion	0-25	Peroneus longus Peroneus brevis	Superficial peroneal nerve

CLINICAL FEATURES

Patients can usually remember the event but often cannot describe the exact mechanism by which their injury occurred. The event may provide some information as to the magnitude of the injury and the likelihood of associated injuries. [23]

A careful examination is needed to determine the status of the skin,

soft tissues, and neurovascular structures, as well as the bones and ligaments. The entire lower leg, including the fibula, should be examined. Combinations of tenderness, swelling, or ecchymosis over the bone, ligaments, or joint line suggest an injury. The stability of the joint should be assessed, especially when these findings are associated with normal x-rays. Based on the physical findings, an anterior drawer, inversion, eversion, or external rotation stress test may be helpful. [23]

Stress testing is often difficult in the acute setting, and analgesic premedication and local or regional anesthesia may be needed. Although pain or tenderness over the structures being stressed suggests an injury, it is difficult to determine the extent of the injury by stress testing alone. Stress x- ray of both ankles provide an objective measurement of the instability and should be obtained at the same time.

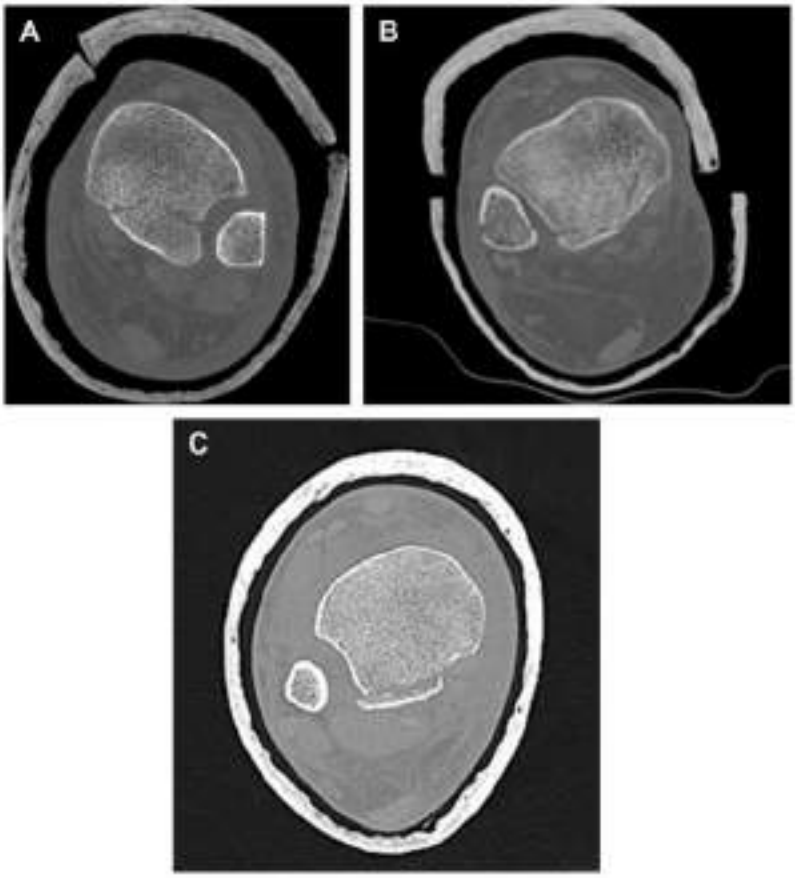
The anterior drawer maneuver evaluates the anterior talofibular ligament. With the ankle in neutral position, a forward force is applied to the heel while a backward force is applied to the tibia. A difference of more than 8 mm compared with the opposite side suggests an injury. An inversion (supination) stress test is performed with the ankle in plantarflexion to test the anterior talofibular ligament and in neutral or slight dorsiflexion to test the calcaneofibular ligament. The ankle is inverted and comparison made to the opposite side. An eversion stress test is performed with the ankle in neutral and test the anterior talofibular ligament and in neutral or slight dorsiflexion to test the calcaneofibular ligament. The ankle is inverted and comparison made to the opposite side. An eversion stress test is performed with the ankle in neutral and tests primarily the superficial deltoid ligament complex.

RADIOGRAPHIC ASSESSMENT

Conventional radiography is indicated for initial diagnosis and treatment of ankle fractures, with identification of posterior malleolar injury best evaluated on lateral view.[24]The ankle fracture is evaluated collectively on

anteroposterior , lateral and a mortise view size of posterior malleolar fragment can be estimated as a percentage of tibial articular surface on lateral view.[25-26] posterior subluxation is defined as any posterior translation of the talus relative to the tibial plafond on alateral radiograph . computed tomography scan should be performed for all posterior malleolar fragments to evaluate fragment size , communition , articular impaction , and syndesmotic disruption.[27-28] HARAGUCHI based on preoperative ct scans classified the fracture into 3 types

type 1 – posterolateral oblique type, type 2 – medial extension type and type 3 – the small shell fragment type.[29]



Picture 4: Haraguchi classification of PMFs, based on CT axial images. (A) Type-I, Posterolateral oblique fragment. (B) Type-II, Medical-extention type. (C) Type-III, Small shell- Shaped fragments at the posterior lip of the tibial plafond [30].

Bartonicek suggested alternative classification based on ct scan, theinvestigators recognized 5 fracture patterns , type 1 – extraincisural fragment with intact fibular notch , type 2 –posterolateral fragment extending into the fibular notch , type 3- posteromedial 2 part fragment involving the medial malle olus , type 4 large posterolateral triangular fragment , type 5 nonclassified , irregular , osteoporotic fragments.[30]

MANAGEMENT OF POSTERIOR MALLEOLUS FRACTURES

INITIAL TREATMENT:

The extremity is usually splinted, iced, and elevated in the emergency room prior to evaluation. A thorough history is taken but rarely gives much useful information. A complete physical examination is performed from head to toe to rule out potential life- threatening or other occult injuries. With this accomplished, the injured ankle is evaluated after the splint is removed.[31]

Ankle fractures should be evaluated as early as possible to avoid swelling and blister formation that would compromise later definitive treatment. If the ankle is grossly distorted, as it might be in a severe injury with subluxation, the subluxation is reduced immediately at the initial examination to avoid skin necrosis and eliminate tension on the neurovascualr structures, even before the radiographic examination is carried out. The foot may occasionally need to be adducted and internally rotated. [31]

After radiographs have been obtained, the ankle is placed in a compression dressing and elevated.

CLOSED REDUCTION :

Satisfactory results depend on anatomic reduction of the fracture and anatomic restoration of the talus in the mortise.

Closed reduction is done for fractures that are stable and open reduction and internal fixation for fractures that are unstable. If stability is defined as the ability of the injured ankle to withstand stress without

displacement, then a stable fracture is one that will not become displaced on the application of physiologic stress, and an unstable fracture is one that will.

In unstable fracture the talus is displaced medially or laterally 2mm or more from its anatomic position.

Closed treatment is carried out in all stable injuries. The displacement if any, is minimal, and no further displacement is expected to occur. Lauge -Hansens supination external rotation, stage- 2 fracture where in the radiologic finding is one of a spiral / oblique fracture of the distal end of the fibula, usually at the level of the joint, has been noted to be the most common stable fracture.

Other stable fractures include stage-1 of supination adduction, pronation abduction and stages 1 and 2 of pronation - external rotation injuries. In all these stable injuries, the fracture is immobilized in a short leg walking cast and held until union, which is usually around 8weeks.

Functional outcome of trimalleolar ankle fractures is found to be worse compared to unimalleolar and bimalleolar fractures [32] a fracture of the posterior tibial margin larger than 5 percent of involved articular surface may lead to the development of posttraumatic arthritis , especially in fractures that involve the weight bearing part of tibiotalar joint [33] a posterior fragment comprising more than 25 percent of intraarticular surface needs to be fixated , and fragments larger than 10 percent that remain persistently unstable after fixation of lateral and medial malleolus.[34]

Isolated, non displaced postrerior malleolar fractures should be treated conservatively. The non surgical treatment of these fractures showed satisfactory outcomes.[35]

The size of posterior malleolar fragment was the main consideration for whether it should be addressed surgically [36] . It was recommended thar if

fragment size greater then 25 percent to 33 percent of articular surface area involved, then it should be reduced and fixed.[37]

Indication of surgery is the size of articular surface carried by a posterior malleolar fragment and its displacement but fom last few years , attention has been paid to restoration of fibular notch and stability of the tibiofibular syndesmosis through fixation of posterior malleolus fractures.[38]

The indications to operative treatment has become more aggressive considering the following benefits offered by anatomic reduction and fixation of posterior malleolus fractures restoration of congruence of articular surface of tibial pilon and thus posterior ankle stability, restoration of competence of posterior tibiofibular ligament and thus syndesmotic stability and restoration of integrity of fibular notch facilitating reduction of distal fibula.[39]

Surgical approaches and open reduction and internal fixation

Internal fixation of posterior malleolar fractures may be performed by direct and indirect techniques. The choice of approach depends on the type of the posterior malleolar fracture and the overall malleolar fracture pattern.

the posterolateral approach allows simultaneous direct reduction of the posterior malleolar fragments and distal fibular fracture. If the posteromedial fragment cannot be visualized and fixed adequately via the same approach it should be adreesed with a separate medial approach extended posteromedially that allows simultaneous reduction and fixation of medial malleolus.[40]

FIXATION OF THE POSTERIOR MALLEOLUS:

Fracture of the posterior malleolus occurs rarely but when it does, it is located on the medial side. It may be continuous with the medial malleolar fragment or be separate. It is fixed from the posteromedial aspect after the medial malleolus has been stabilized by using one or two 4mm AO cancellous screw. [41]

The fractured posterior malleolus is located laterally at the site of attachment of the posterior tibiofibular ligament in the “Volkmann triangle” and is sometimes referred to as Volkamanns fracture.

It has been customary to fix the fracture only if it constituted 25% or more of thearticular surface. It is felt that if there is an associated tibiofibular instability or diastasis, fixation of the fractured posterior malleolus restores maximal stability, it would reduce the incidence of secondary degenerative changes at a later date.[41]

Reduction and fixation of the lateral malleolar fracture brings about reduction of the posterior malleolar fracture in more than three quarters of the cases because the two malleoli are connected by the posterior tibiofibular ligament. In the remaining cases reduction is usually effected by pulling the foot forward and then maximally dorsiflexing the ankle as well as dorsiflexing the big toe at the metatarsophalangeal joint. This maneuver aids in reduction of the fragment by tensing the posterior capsule of the ankle and the flexor hallucis longus tendon.

If the fragment is reduced, it is fixed with one or two 4- mm cancellous screwsplaced in an anteroposterior direction through small stab incisions made anteromedially. In anteroposterior placement the fragment may be pushed apart by the drill bit or the screw, and if the screw threads lie across the fracture line, an adequate lag effect may be prevented.

Recent work, suggests that if the posterior malleolar fragment is reduced, it remains stable and will not need fixation as long as the fibular fracture has been adequately reduced and stabilized.

If the fragment remains anatomically unreduced, an open reduction is carried out, through an extended posterolateral approach . The posterior aspect of the tibia and the fractured fragment is exposed by enlarging the interval between the peroneal tendons and the flexor hallucis longus muscle. In a direct posterolateral approach, the incision lies between the tendo Achillis and the peroneal tendons and leads directly to the interval

between the peroneal brevis tendon and the flexor hallucis longus muscle. The articular component of the fracture cannot be visualized, and for this reason it is important that the entire extra - articular extent of the fracture be clearly seen to ensure adequacy of reduction before proceeding to fixation of thefragment.[41]

Reduction is effected with a small periosteal elevator. It is inserted into the fracture site while the foot is held in plantar flexion to ease the tension on the posterior capsule. The fragment is gently eased inferiorly by the elevator at the same time that it is pushed anteriorly with the thumb. The reduced fragment is held with two Krischner wires, and an intra operative lateral view of the ankle is obtained. After confirmation of the reduction, the fragment is fixed with two 4mm AO cancellous screws with a washer or a buttress plate preferably t shaped plate. The choice of implants depends on the size and bone quality of the posterior malleolar fragment.[42] studies revaled that a higher strength of posterior plates compared with anteroposterior and posteroanterior screws in osteoporotic bones , plating is preferred . . The screws are placed at right angles to the fracture just above the plafond and in an oblique direction, posterolateral to anteromedial.

The fracture may be reduced through a posteromedial exposure made for the medial malleolus, but it is less straight forward and less easy than from the posterolateral approach.

POST OPERATIVE MANAGEMENT:

Following stabilization of the fractures, the pneumatic tourniquet is released and hemostasis obtained.

The ankle is immobilized in well padded firm dressing incorporated with a posterior plaster splint that will hold the ankle at right angle and prevent any plantar flexion.

If the bone quality is good and the fixation is secure, the splint can be removed in 2 to 4 days and replaced with a removable splint or fracture

boot. Range-of-motion exercises are then begun. Weight bearing is restricted for 6 weeks, after which partial weight bearing can be started if the fracture is healing well. Full weight-bearing is allowed after 12weeks.[43]

If skin conditions, bone quality, or other factors have prevented secure fixation, the fracture must be protected longer.

COMPLICATIONS AND THEIR MANAGEMENT

Symptomatic malunion and non union of posterior malleolar fragments may be treated by joint preserving osteotomies or secondary anatomic fixation if no or only mild posttraumatic arthritis is present .[44]

Posttraumatic arthritis can result from direct cartilage damage at the time of injury or residual malalignment of posterior malleolar fractures. The fact that there is a higher incidence and severity of posttraumatic arthritis with the presence of increasing size of a posterior tibial fragment probably reflects the overall severity of injury compared with isolated fibular fractures and bimalleolar fractures.[45]

Therefore we aim to study the functional outcome of ankle fractures associated with fracture of posterior malleolus treated with various methods ranging from conservative treatment to open reduction and internal fixation.

AIMS AND OBJECTIVES

To study the functional outcome of ankle fractures associated with fracture of posterior malleolus.

Macko VW et al[46] reviewed about the joint-contact area of the ankle and the contribution of the posterior malleolus. Eight ankles from fresh cadavers were tested under simulated clinical conditions to determine the effect of increasing the size of the posterior malleolar fracture on the contact area of the ankle joint and on the distribution of joint pressure. The surface area of contact decreased with increased size of the posterior malleolar fragment. However, the documented changes were smaller than expected on the basis of the findings of Ramsey and Hamilton; they reported a 42 per cent reduction in contact area with only a one-millimeter lateral shift of the talus, which clinically would be associated with a similar one-millimeter shift of the distal tibial fragment. In addition, clinical experience has shown a high rate of post-traumatic degenerative arthritis associated with an inadequately reduced one-half-size posterior fragment. There were considerable changes in the load-distribution patterns, with increased confluence and concentration of loads as the size of the fragment was increased. In plantar flexion, many specimens had three separate areas of contact between the tibia and the talus. With increased size of the posterior fragment, the three areas of contact always joined to become one. Similarly, for all positions of the ankle, increased size of the posterior fragment caused decreases in the contact area. The maximum loss of contact area was 35 per cent for specimens with one-half-size fractures that were tested in the neutral position.

Ferries JS et al[47] **1994** conducted study on twenty-five patients with trimalleolar ankle fractures were evaluated using both conventional radiography and computed tomography (CT) to determine the size of the posterior fragment along with other fracture characteristics. Plain radiograph measurements indicated very poor inter- and intraexaminer reliability. When compared to the CT scan measurement, 54% of the plain radiographic readings revealed > 25% error. Plain radiographic

interpretations erred in most cases by overrating the size of the fragment, but major underestimations also occurred. The larger size fragments showed more error than the smaller ones. This information confirms the clinical suspicion that the lateral radiograph is unreliable in assessing the posterior fragment size.

Koval KJ et al[48] 2007 conducted study on twenty-one patients who had a positive ankle stress test (>or=5 mm clear space widening) after isolated Weber B lateral malleolus fracture were further evaluated by MRI to determine the status of the deep deltoid ligament.Twenty-one patients had an MRI after a positive ankle stress test and comprised the study group. There were 12 men and 9 women with an average age of 27 years (range, 16-62 years). Absolute medial clear space measurement on stress testing ranged from 5 to 8 mm. In all, 19 of 21 patients (90%) had evidence of partially torn deep deltoid ligament on MRI and were treated nonoperatively, whereas two patients had MRI findings of a complete deep deltoid injury and underwent surgical treatment.. All fractures united without evidence of residual medial clear space widening or posttraumatic joint space narrowing. Of the 15 patients who were available for 1 year minimum follow-up and agreed to come back for clinical and radiographic evaluation, 14 had an AOFAS score of 100, with the remaining patient having a score of 85.. They identified and provide effective nonoperative care to 19 patients who otherwise might have underwent operative treatment after an isolated lateral malleolus fracture.

Tejwani NC et al[49] 2010 compared clinical and functional outcomes of surgically treated trimalleolar fractures with bimalleolar and unimalleolar ankle fractures.A prospective database was established to enroll all unstable ankle fractures treated operatively at the institution from October 2000 to July 2005. Demographic data on 456 patients, who sustained an unstable fracture of the ankle and were treated surgically, were entered into a database, and the patients were prospectively followed up. Of these

309 patients who had at least 1-year follow-up, 54 patients sustained an ankle fracture with involvement of the posterior malleolus. Two hundred fifty-five patients had an ankle fracture without involvement of the posterior malleolus. Of the 54 posterior malleolus fracture, 20 underwent fixation of the posterior malleolus. All patients were followed up at 3 months, 6 months, and 12 months after surgery and assessed functionally with American Orthopaedic Foot and Ankle Society Scores. At 1-year follow-up, all patients improved their function and pain status. Using the American Orthopaedic Foot and Ankle Society, patients with posterior malleolus fracture were significantly worse both for total score ($p = 0.004$) and pain function ($p = 0.002$). At 2-year follow-up, there was no significant difference in a smaller group of patients (41 patients). There was a significant difference in outcomes comparing patients with unstable ankle fractures associated with and without posterior malleolus fractures. The presence of a posterior malleolus fracture may indicate higher energy of injury, and it does seem to result in worse outcomes at 1 year, but this seems to even out over time as was seen at 2-year follow-up in a smaller group of patients.

AbdelgawadAA et al[50] 2011 described the technique and results of treatment of the posterior malleolus by direct reduction through the posterolateral approach to the ankle. The decision to fix the posterior malleolus was determined by its size and displacement. A total of 12 consecutive patients underwent the posterolateral approach to reduce the posterior malleolus, and these were fixed by posterior plate. Ten patients had adequate (<2-mm displacement of the articular surface) radiologic reduction at the final follow-up visit. There were 2 cases of 2 mm or more of articular surface displacement at the final follow-up visit (1 patient had 2-mm displacement noted in the immediate postoperative period and 1 patient had adequate reduction in the beginning but was displaced with additional follow-up). The posterolateral approach to the ankle is a useful

tool to treat certain cases of posterior malleolus fracture. It allows good visualization and stable fixation of the posterior malleolus.

Yu Get al[51] 2011 evaluated the operative procedure and the clinical effectiveness of open reduction and internal fixation in the treatment of posterior malleolus fractures. Between June 2005 and December 2008, 46 patients with posterior malleolus fractures were treated with open reduction and internal fixation and followed up. There were 29 males and 17 females with an average age of 47.7 years (range, 19-76 years). Fractures were caused by sprain in 17 cases, by falling in 15 cases, by traffic accident in 12 cases, and by other reasons in 2 cases. The locations were left ankle in 25 cases and right ankle in 21 cases. There were 6 simple posterior malleolus fractures, 13 lateral and posterior malleolus fractures, and 22 trimalleolar fractures, and 5 lateral and posterior malleolus fractures accompanying by injury of deltoid ligament of ankle. According to Lauge-Hansen classification system, 13 cases and 9 cases were rated as supination-external rotation type III and type IV respectively, and 18 cases as pronation-external rotation type IV. According to Naoki's classification of posterior malleolus fractures, there were 29 cases of posterolateral-oblique type, 11 cases of medial-extension type, and 6 cases of small-shell type. Seven patients underwent emergency operation and 39 patients underwent selective operation. Two patients developed superficial infection, which was cured after dressing change, and the other incisions healed by first intention. Forty-six patients were followed up 37 months on average (range, 18-63 months). All fractures healed after 3 to 6 months (mean, 4.3 months). One patient developed lateral sural cutaneous nerve injury, and 9 patients had mild weight-bearing pain or discomfort. The results of American Orthopaedic Foot and Ankle Society (AOFAS) ankle and hindfoot score were excellent in 17 cases, good in 21 cases, and fair in 8 cases with an excellent and good rate of 83%. The mean visual analogue scale (VAS) score was 1.9

(range, 0-5).The anatomic reduction and internal fixation can achieve the satisfactory results in the treatment of posterior malleolus fractures. The best treatment and fixation methods should be chosen based on different types of posterior malleolus fractures.

A retrospective study of posterior malleolus fractures conducted by **Hai-lin Xu**[52] showed that The average AOFAS score was 95.9, excellence rate was 92.2 %, and average VAS scores for degree of fracture pain during rest, active movement, and weight-bearing walking were 0.15, 0.31, and 0.68, respectively. Thirty-six cases showed arthritic manifestations. Ankle joint mobility along all directions on the injured side was lower than that on the unaffected side. There was no obvious difference in treatment effect between the fixed and unfixed posterior malleolus fragment groups for all and for fragment size of <25%, between fixing the posterior malleolar fragment from front to back or from back to front. There was a distinct difference in the treatment effect between the articular surface eveness and un eveness for all and for fragment size >25%. Therefore, he concluded that restoration of an even articular surfecr especially when fragment size >25% should be attempted during treatment.

The study conducted by Ewout S. Veltman et al[53] **reviewed** the current data on the long-term outcomes of posterior malleolar fractures, with special emphasis on the role of the type of treatment, surgical approach, and reduction and internal fixation. Of 68 initially relevant studies, 19 met the inclusion criteria. A total of 886 fractures were identified in 885 patients. The mean sample size-weighted follow-up period was 3.7 years. Comparable results were achieved when comparing open reduction and internal fixation to conservative treatment for posterior malleolar fractures.

Verhage SM et al[54] analysed the influence of several combinations of malleolar fractures on long-term functional outcome and development of osteoarthritis.Retrospective cohort-study on operated (1995–2007)

malleolar fractures. Results were assessed with use of the AOFAS-questionnaires, VAS-pain score, dorsiflexion restriction (range of motion) and osteoarthritis. There was no significant difference in isolated fibular fractures with or without additional deltoid ligament injury. In addition, no functional differences were found between bimalleolar and trimalleolar fractures. Surprisingly, poor outcomes were found for isolated medial malleolar fractures. Development of osteoarthritis occurred mainly in trimalleolar fractures with a posterior fragment larger than 5 %. The results of the study show that long-term functional outcome is strongly associated to medial malleolar fractures, isolated or as part of bi- or trimalleolar fractures. More cases of osteoarthritis are found in trimalleolar fractures.

Karaca S et al[55] evaluated treatment effect and importance of posterior malleolus (PM) fixation in surgically treated trimalleolar fractures.A total of 57 cases of ankle joint fracture involving PM and treated with open reduction and internal fixation technique between 2004 and 2011 were evaluated. PM fixation was performed with cannulated screws in 46 cases, and in 11 cases, PM plate was used. All patients were assessed using American Orthopaedic Foot and Ankle Society (AOFAS) score and Visual Analog Score (VAS) pain scale. Ankle joint mobility was also compared with unaffected side. Mean follow-up period was 44.6 months (range: 24–108 months). There were 36 female patients and 21 male patients between 23 and 85 years of age (mean: 55.9 years). Average time to surgery was 1.1 day (range: 1–3 days). According to AOFAS assessment, result was excellent in 21 patients and good in 26 patients. Mean VAS score when resting was 1.1, and mean score was 1.3 when walking (range: 0–10). When compared with uninjured side, there was no significant difference in plantar flexion of ankle ($p=0.325$) but there was significant difference in dorsiflexion of ankle joint ($p<0.001$).Anatomical reduction and rigid internal fixation of PM provide satisfactory clinical and functional outcomes even in elderly patients where bone quality may make

adequate fixation difficult. Fixation of even small PM fragments can facilitate rehabilitation by creating more stable construction.

Solan MC and Sakellariou A[56] reviewed about posterior malleolus fractures.The posterior malleolus component of a fracture of the ankle is important, yet often overlooked. Pre-operative CT scans to identify and classify the pattern of the fracture are not used enough. Posterior malleolus fractures are not difficult to fix. After reduction and fixation of the posterior malleolus, the articular surface of the tibia is restored; the fibula is out to length; the syndesmosis is more stable and the patient can rehabilitate faster. There is therefore considerable merit in fixing most posterior malleolus fractures. An early post-operative CT scan to ensure that accurate reduction has been achieved should also be considered.

Gawali RS et al[57] conducted study on management of Fracture of Posterior Malleolus, Trimalleolar Fracture, Fracture Dislocations, and Syndesmosis Injury of Ankle Joint. From January 2013 to March 2015, 35 patients with syndesmotic ankle injury and trimalleolar ankle fractures admitted to the Government Medical College, Latur, India, were operated and followed up prospectively.Mean age of patients is 35 years (25–60 years). Fracture union was seen radiologically in 3 to 4 months depending on fracture geometry. We achieved good to excellent results of 90%. They concluded that malleolar fractures encountered in clinical practice need thorough assessment and meticulous surgical intervention, as they are associated with injury to ligament complex, i.e., ligament is a key structure in the stability of ankle mortise. Abduction and external rotation types of injuries are the most common types to be seen. They achieved stable fixation and performed early mobilization of the ankle joint, which limits the complications of mainly ankle stiffness.

Kaye Aet al[58] reviewed about posterior malleolar ankle fractures. All fractures were classified according to Mason and Molloy classification (BOFAS 2015, FAI 2017) based on CT scans obtained pre-operatively.

This dictated the treatment algorithm. Type 1 fractures underwent syndesmotic fixation. Type 2A fractures underwent ORIF through a posterolateral incision, and type 2B and 3 fractures underwent ORIF through a posteromedial incision. The patient remained NWB for 6 weeks postoperative. Data was collected from December 2014 to July 2017.Patient related outcome measures were obtained in 50 patients with at least 6 month follow up (mean 18 months). According to Mason and Molloy classification there were 17 type 1, 12 type 2A, 10 type 2B and 11 type 3. The mean OMAS for type 1 was 75.9 (Range 30–100, SD 18.4), type 2A 75.0 (range 35–100, SD 21.3), type 2B 74.0 (range 55–100, SD 13.7) and type 3 70.5 (Range 35–100, SD 17.1). An increase in OMAS of 4 is clinically significant. They demonstrated an improvement in OMAS for all posterior malleolar fractures with the treatment algorithm applied using the Mason and Molloy classification.

Smeeing DP et al[59] described the isolated posterior malleolar fracture, the possible associated injuries, the diagnostic work-up and therapeutic consequences. They presented a case of a 26-year-old male patient who sustained an isolated posterior malleolar fracture with 4.5 years follow-up. This case report and literature review shows that isolated posterior malleolar fractures might occur as part of a more complex ankle injury, in combination with a fracture of the lower leg or after high energy trauma. Physicians should be aware of these associated injuries. Diagnostic work-up should include X-rays of the knee and lower leg and a CT scan of the ankle. If diagnosed and treated properly, isolated posterior malleolar fractures have a good long-term functional outcome.

Zhong Set al[60] compared clinical and radiographic outcomes of posterior malleolar fractures (PMF) treated with lag screws from anterior to posterior versus posterior to anterior approach. They retrospectively analyzed 48 patients with trimalleolar fractures who underwent open reduction and internal fixation (ORIF) with either posteromedial (PM) or posterolateral

(PL) approaches between January 2012 and December 2014. Fixation of the posterior malleolus was made with anteroposterior screws in 20 patients using the PM approach and posteroanterior screws in 28 patients using the PL approach. The American Orthopedic Foot and Ankle Society (AOFAS) scores and range of motion (ROM) of the ankle were used as the main outcome measurements, and results were evaluated at the 6-month, 12-month and final follow-up. Postoperative radiographs and computed tomography scans were used to evaluate the residual gap/step-off .The mean duration of follow-up regardless of the approaches was 21.1 months (range, 15–54 months). None of the patients developed delayed union or nonunion. Functional bone healing was obtained in all patients at 10.7 weeks (range, 8–16 weeks). The mean AOFAS scores of the PM group at the postoperative 6-mouth, 12-month, and final follow-up were 91.4 (range, 82–100), 92.5 (range, 84–100), and 92.9 (range, 86–100), respectively. In the PL group, the mean AOFAS scores were 89.9 (range, 72–100), 91.4 (range, 77–100), and 91.9 (range, 77–100), respectively. There were no significant differences between the two approaches in AOFAS scores and ROM of the ankle in each period postoperatively ($P > 0.05$)..Satisfactory results were obtained by using the two approaches for fixation of posterior malleolus, and the approaches have similar clinical and radiographic outcomes.

Stephen McHale[61] reviewed retrospective cohort study of operatively treated ankle fractures involving the posterior malleolus. 75 patients were included, and 31 returned Manchester-Oxford Foot and Ankle (MOXFQ), EQ-5D-3 L, 5-point Likert satisfaction questionnaires. Mean age was 56.2 years, 68% were female, mean ASA was 1.72, 6.7% were diabetic, and average surgical time was 75.7 min. Results: Overall, the MOXFQ summary score was 26.9 with the pain domain showing the most severe score 32.4 . The EQ-5D VAS index was 0.75 (0.24). Larger PM size was associated with more anatomical reduction (58.8%, n = 20 of <10% vs.

90.9%, n = 10 of >30%) and larger sized fragments were more likely to be fixed posteriorly. Best PROMs were observed in PM fragments <10%, and the worst in fragments 10-20%. A tendency towards more secondary surgery was observed with posterior subluxation 21.9%. They concluded that Patients with fragments >10% have an intra-articular injury. We recommend direct anatomic reduction and rigid internal fixation.

Evers Jet al[62] investigated the effect of a posterior malleolar fragment (PMF), with < 25% ankle joint surface, on pressure distribution and joint-stability. There is still little scientific evidence available to advise on the size of PMF, which is essential to provide treatment.A total of 12 cadaveric ankles were assigned to two study groups. A trimalleolar fracture was created, followed by open reduction and internal fixation. PMF was fixed in Group I, but not in Group II. Intra-articular pressure was measured and cyclic loading was performed.Contact area decreased following each fracture, while anatomical fixation restored it nearly to its intact level. Contact pressure decreased significantly with fixation of the PMF. In plantarflexion, the centre of force shifted significantly posteriorly in Group II and anteriorly in Group I. Load to failure testing showed no difference between the groups.Surgical reduction of a small PMF with less than 25% ankle joint surface improves pressure distribution but does not affect ankle joint stability.

Tosun B et al[63] assessed the effects of posterior malleolus fixation on the functional and radiological outcomes.Reduction quality, development of posttraumatic ankle osteoarthritis, and functional outcomes in 49 consecutive trimalleolar ankle fractures were evaluated retrospectively in patients with and without posterior malleolus fixation. Group I consisted of 29 patients, in which posterior malleolar fracture was left untreated. Twenty patients in Group II, posterior malleolar fragment was fixed directly by screws alone or plate screw. Twenty-one of these 49 patients were male (43%). The mean age was 47 years (range 20-82 years). The mean

followup was 12 to 51 months with a mean of 15 months (range 12-51 months). Statistically significant differences were found between Group I and Group II in terms of ankle arthrosis. American Orthopaedic Foot and Ankle Society score was significantly lower in Group I compared to Groups II.These results demonstrated that posterior malleolar fracture fixation is closely related to successful radiological and functional outcomes after trimalleolar fractures. Transyndesmal screw fixation may not be needed in the cases where the posterior malleolar fracture fixated. For these reasons, we recommend that all posterior malleolar fractures have to be fixed regardless of size.

Bergman Cet al[64] highlighted the anatomic features of posterior malleolar ankle fractures, the classification schemes used, and discusses the various nonsurgical and surgical methods currently used.The posterior malleolar fragment is frequently involved in rotational ankle fractures, but diagnosis and definitive management remains controversial. Ankle fractures with a posterior malleolar component that are not identified and treated in a timely manner may contribute significantly to future comorbidities, including continued pain, instability, and the development of arthritis.

Mason LW et al[65] reviewed about posterior malleolar ankle fractures. All fractures were classified on the basis of computed tomographic (CT) scans obtained preoperatively. This dictated the treatment algorithm. Type-1 fractures underwent syndesmotic fixation. Type-2A fractures underwent open reduction and internal fixation through a posterolateral incision, type-2B fractures underwent open reduction and internal fixation through either a posteromedial incision or a combination of a posterolateral with a medial-posteromedial incision, and type-3 fractures underwent open reduction and internal fixation through a posteromedial incision.Patient-related outcome measures were obtained in 50 patients with at least 1-year follow-up. According to the Mason and Molloy

classification, there were 17 type-1 fractures, 12 type-2A fractures, 10 type-2B fractures, and 11 type-3 fractures.. They demonstrated an improvement in the Olerud-Molander Ankle Score for all posterior malleolar fractures with the treatment algorithm applied using the Mason and Molloy classification. Mason classification type-3 fractures have marginally poorer outcomes, which correlates with a more severe injury; however, this did not reach significance.

Mertens M et al[66] assessed the functional outcome and quality after plate osteosynthesis of the posterior malleolus, identified the main drivers of outcome and aimed to determine which patient and fracture type are eligible for plate osteosynthesis of the posterior malleolus.A prospective patient cohort of 50 patients with an ankle fracture including the posterior malleolus underwent plate osteosynthesis via a posterior approach, and was compared to a retrospective patient cohort of 85 consecutive patients who did not. Twenty-five demographic, operative and postoperative characteristics were assessed. Outcome was recorded using questionnaires: AOFAS, EQ-5D .Direct reduction and plate osteosynthesis of posterior malleolus fractures was inferior to non-operative treatment. Subanalysis of trimalleolar fractures revealed that the outcome of plate osteosynthesis was equal. Both fracture type and plate osteosynthesis were independent drivers of the outcome; Haraguchi type 3 posterior malleolus fractures were associated with the best functional outcome and quality of life scores. Comorbidity, age, postoperative complications and reintervention largely determined the outcome. There was no indication for routine plate osteosynthesis of all posterior malleolus fractures. Careful patient selection, less invasive surgery and modified postoperative rehabilitation seem mandatory to improve the outcome and prevent adverse effects.

Abarquero-DiezhandinoA et al[67] analysed the clinical and functional outcomes of ankle fractures involving the posterior edge, treated surgically

without direct reduction of the third malleolus. They performed a retrospective study of 45 patients aged under 60, who we classified into three groups in terms of the percentage of joint involvement of the posterior fragment (<10%, 10%–25% and >25%) assessing the functional outcomes using the visual analogue pain scale (VAS), the AOFAS scale (American Orthopedic Foot and Ankle Society) of the ankle and hindfoot we also analysed the degree of osteoarthritis with weight-bearing radiography, at least one year following the injury.The mean VAS pain score of the sample was 1.1 (0–5) at rest and 3 (0–8) on exercise; 88.4±10.1 on the AOFAS scale. Up to 18% of the patients developed radiographically significant osteoarthritis in the short and medium term (between 12 and 73months, with a mean of 33months). Of the patients, 55.6% had involvement of between 19% and 25% of the joint surface. We found that a larger posterior fragment size related to a greater degree of early-onset osteoarthritis ($p<0.03$) and poorer AOFAS scores ($p<0.01$).Ankle fractures involving the posterior malleolus seem to contribute to the development of early-onset osteoarthritis with functional limitation in young adults.

Haraguchi N and Armiger RS[68] reviewed about mechanism of posterior malleolar fracture of the ankle. Fifteen cadaver ankles were subjected to fracture loading that replicated the Lauge-Hansen pronation-external rotation mechanism. An axial load was applied to each specimen, which was mounted on a materials testing machine, and the foot was rotated externally to failure..Posterior malleolar fracture occurred in 7 specimens. Of these, 1 was an intra-articular fracture, another was a fracture involving the entire posterior tibial margin consisting of 2 fragments: that of the posterior tubercle and that of the posteromedial margin of the tibial plafond, with the former judged to be a consequence of avulsion by the posterior inferior tibiofibular ligament and the latter a consequence of axial loading from the talus. In the remaining 5 specimens, the posterior

malleolar fracture was a small extra-articular avulsion fracture.Fractures at the posterolateral corner of the distal tibia were shown to be avulsion fractures attributed to the posterior inferior tibiofibular ligament and produced by external rotation of the talus. A fracture involving the entire posterior tibial margin consisting of 2 fragments can be produced by a combination of avulsion by the posterior inferior tibiofibular ligament and axial loading from the talus.

Chen Fet al[69] investigated the effectiveness of fixation the posterior malleolus .The clinical data of 86 trimalleolar fracture patients who were admitted between January 2015 and September 2019 and met the selection criteria were retrospectively reviewed. There were 29 males and 57 females; the age ranged from 26 to 82 years with a mean age of 55.2 years. According to Haraguchi's classification, 38 patients were in type Ⅰ group, 30 patients in type Ⅱ group, and 18 patients in type Ⅲ group. The fixation of the posterior malleolus was performed in 23, 21, and 5 patients in type Ⅰ, Ⅱ, and Ⅲ groups, respectively. The American Orthopedic Foot and Ankle Society (AOFAS) ankle and hindfoot score was used to evaluate ankle function, including pain, quality of daily life, joint range of motion, and joint stability. The AOFAS scores were compared between fixation and non-fixation groups in each group. All patients were followed up 12-36 months with a mean time of 16.8 months. At last follow-up, 6 patients were found to have suboptimal ankle planarity, including 2 patients (5.3%) in the type Ⅰ group and 4 patients (13.3%) in the type Ⅱ group, with no significant difference between groups (χ^2=6.566, P=0.161). The ankle joints of all the patients in each group showed mild degeneration; the fractures all healed well and no delayed union or nonunion occurred. There was no significant difference in the fracture healing time and full weight-bearing time between groups (P>0.05).. At last follow-up, the total scores and pain scores of the AOFAS scores in the type Ⅱ group were significantly lower than those in

the type Ⅰand Ⅲ groups (*P*<0.05), there was no significant difference between groups in the scores for the quality of daily life, joint range of motion, and joint stability between groups (*P*>0.05). There was no significant difference in any of the scores between the unfixed and fixed groups, except for the pain and quality of daily life scores, which were significantly lower (*P*<0.05).

Jeyaseelan et al[70] studied Fixation of the posterior malleolus was associated with a statistically significant improvement in patient outcomes. Mean MOXFQ score in the unfixed posterior malleolus group was 24.03 (0 - 62), compared to 20.10 (0 - 67) in the fixed posterior malleolus group (p = 0.04). Outcomes were worse with increasing size of posterior malleolar fragment. Metalwork-related issues were higher in the posterior malleolus fixed group (24/160 (15%) versus 10/160 (6.2%)) and re-operation rate was double. This study demonstrates that in the practical setting of a major trauma unit, fixation of the posterior malleolar fracture leads to improved patient outcomes but with increased metalwork risks and reoperation rates.

Neumann AP et al[71] assessed the medium-to-long-term clinical and functional outcome of ankle fractures with a PM fragment in a larger patient population.One hundred patients (69 women, 31 men, average age 60 years) with ankle fractures including the PM were evaluated clinically and radiographically. Patients with Bartoníček–Rammelt type 3 and 4 fracture displayed a significant female preponderance. Fixation of the PM was performed in 63% and tailored to the individual fracture pattern. Internal fixation of the PM fragment was negatively correlated with the need for syndesmotic screw placement at the time of surgery (p = 0.010). At an average follow-up of 7.0 years, the mean Foot Function Index (FFI) was 16.5 (*SD: 21.5*), the American Orthopedic Foot & Ankle Society (AOFAS) ankle/hindfoot score averaged 87.5 (*SD: 19.1*). The maximum score of 100 was achieved by 44% of patients.. Range of

motion was within 3.4 (*SD: 6.63*) degrees of the uninjured side. The size of the PM fragment had no prognostic value. There was a trend to lower outcome scores with slight anterior or posterior shift of the distal fibula within the tibial incisura .With an individualized treatment protocol, tailored to the CT-based assessment of PM fractures, favorable medium and long-term results can be expected.

MATERIALS AND METHODS

SOURCE OF DATA

The study was a prospective study to evaluate the functional outcome of ankle fractures associated with fracture of posterior malleolus". The patients operated at Dayanand Medical College & Hospital, Ludhiana from 1st November, 2019 to August 2021 were included in this study. The performa was filled at the time of admission with demographic data and details of injuries recorded.

METHOD OF COLLECTION OF DATA

After obtaining approval from the institutional ethical committee, patients were enrolled in the study on the basis of inclusion / exclusion criteria. The study was carried out by taking an informed consent from the patients willing to be a part of the study.

Collection of data of patients presenting with ankle fractures with involvement of posterior malleolus will be as follows

- History
- Clinical examination both systemic and local
- Radiological examination using Xray (ANTEROPOSTERIOR, LATERAL, MORTISE Views), CT scan and other imaging modalities if necessary
- Investigations - routine and others
- Diagnosis - clinical and radiological
- METHOD OF TREATMENT – Conservative or surgical
- Surgical: External Fixator or definitive fixation - depending upon the size of swelling), Internal fixation will be done if required after swelling subsides.
- Surgical approach, nature of implant.
- Routine - antibiotics and analgesics / anti inflammatory drugs
- Post op evaluation - clinical examination and xray ankle (AP and Lateral view)

INCLUSION CRITERIA:

- Patients with posterior malleolus fracture - both open and closed injuries
- All patients18 years and above
- Patients willing to participapte in the study

EXCLUSION CRITERIA:

- Patients with pre-existing ankle arthritis
- Patients not willing to participate in the study.
- Patients with ankle arthrodesis
- Patient with pathological fracture

Data include was patient age and gender, mechanism of injury, date of injury, date of surgery, operative notes. The follow up included details of mobilisation, weight bearing, complications and need for additional treatment. The minimum follow up period was 6 months or completion of functional recovery after fracture union, whichever is later. Patients was assessed at final follow up as per the AOFAS scoring system.

Follow up was done at 4 weeks, then at 1 month, and then every month. Patient was assessed clinically for fracture healing, range of motion, and was radiographically checked for the progress of fracture healing. Radiographic union was defined as bridging trabeculations across the fracture site or absence of fracture line

AOFAS SCORE (American Orthopaedic Foot And Ankle Society)- This method of ankle functional assessment combines patient as well as clinician based score It consists of 100 points allotted to following parameters - Pain (40), function (50), alignment (10). Functional assessment was done at 6 months of follow up in prospective patients. The score at 6 months was taken as final functional outcome in all patients. Results were graded as Excellent (score - >90), Good (score – 75-89), Acceptable (score – 50-74) or Poor (score - <50).

OBSERVATION AND RESULTS

A total of 18 patients of posterior malleolus fracture which were treated with in Department of Orthopaedics, Dayanand Medical College & Hospital, Ludhiana in a period between 1st November, 2019 to August, 2021 were included in the study. Out of these 18 patients, 1 patient expired. The following observations were made in preoperative, per-operative and post-operative periods.

Table 2 Distribution of patients according to age (n=17)

AGE	No. of cases	Percentage
< 40	5	29.4%
41-60	6	35.3%
> 60	6	35.3%

This table shows distribution of patients in various age groups.

Minimum age was 29 years and maximum was 75 years. More than 70% of the patients were above the age of 40 years. This shows that fracture is mostly seen in 4th to 7th decade. The follow up period was 6 months to 24 months with average follow up is 15 months .

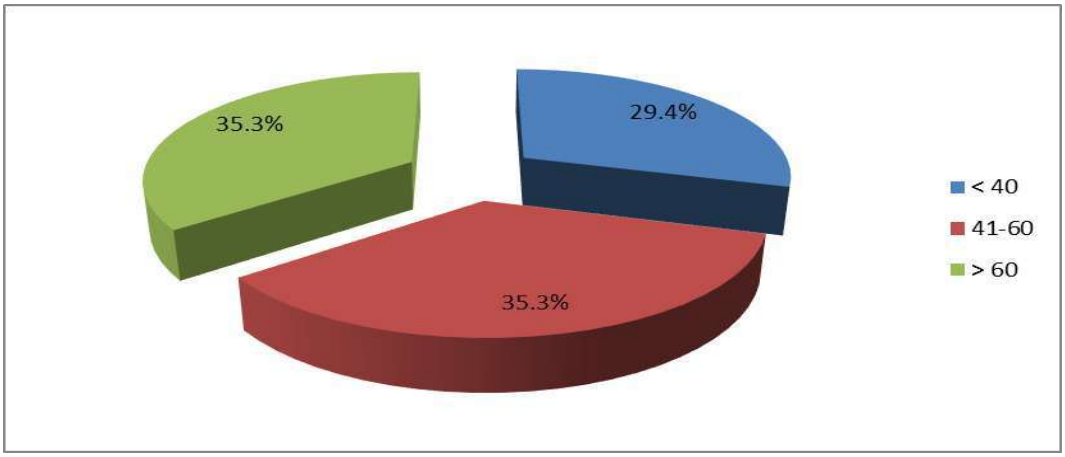


Figure 1 Distribution of patients according to age (n=17)

Table 3 Distribution of patient according to sex

SEX	No. of cases	Percentage
F	7	41.2%
M	10	58.8%
Total	17	100.0%

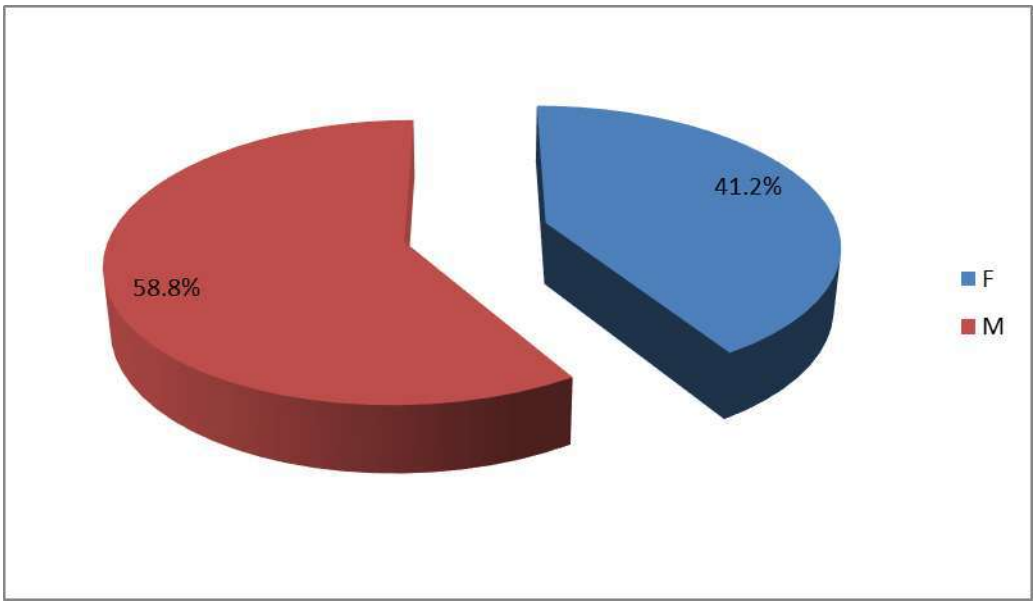


Figure 2 Distribution of patient according to sex

Table 4 Distribution of patients according to mode of injury

Mode of injury	No. of cases	Percentage
FALL	3	17.6%
RTA	14	82.4%
Total	17	100.0%

This table shows the distribution of patients according to mode of injury. Majority of patients in this series were admitted with history of Road Traffic Accidents (14 patients, 82.4%). Rest of the patients were admitted due to domestic fall (3 patients, 17.6%). Therefore road traffic accidents is one of leading cause of ankle fractures involving the posterior malleolus.

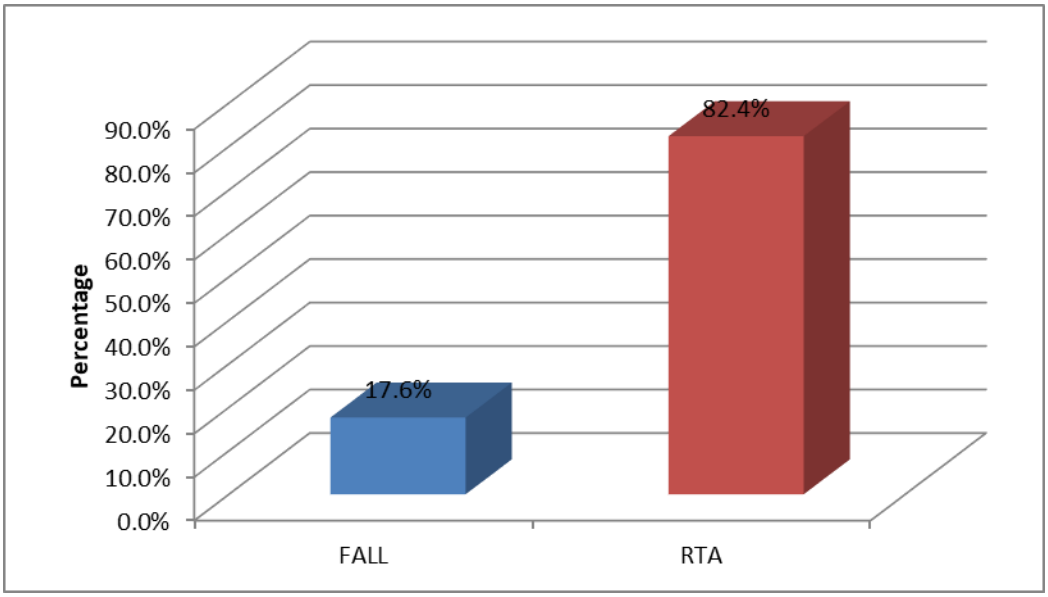


Figure 3 Distribution of patients according to mode of injury

Table 5 Distribution of patients according to lauge hensen Classification

Classification of fracture_Lauge Hansen	No. of cases	Percentage
PER	6	35.3%
SER	11	64.7%
SAD	0	0%
PAB	0	0%
Total	17	100.0%

More than half of the patients have SER (64.7%) type of ankle fracture while 35.3% of patients have PER type of injury. no patients have supination adduction and pronation abduction type of injury . therefore supination external rotation and pronation external rotation are the most common type of injuries . 3 out of 6 patients of PER type injury has been fixed while 4 out of 11 patients of PER type of injury has been operated.

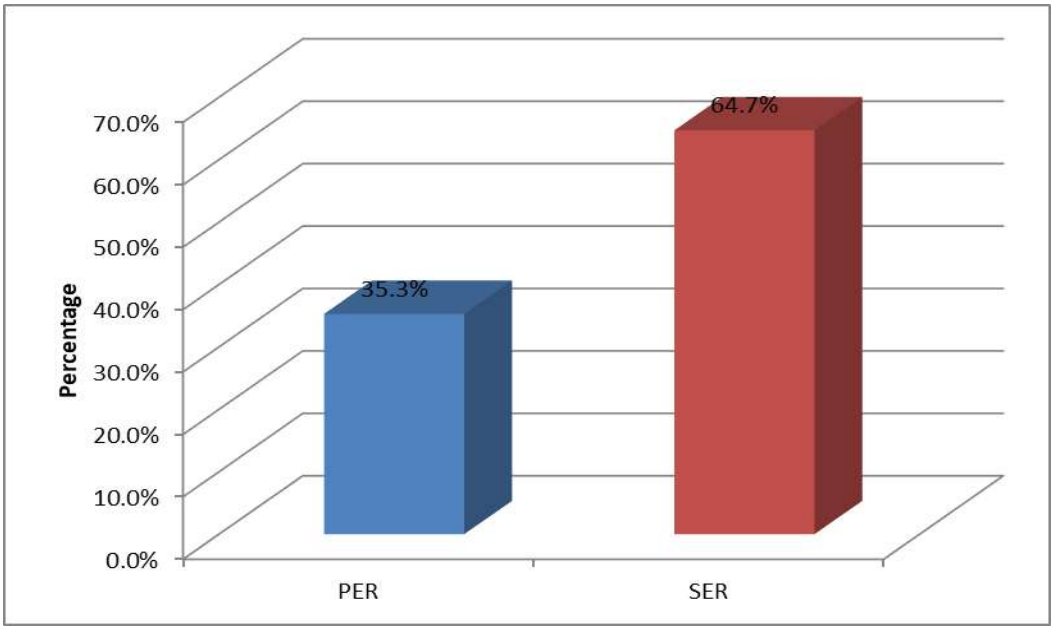


Figure 4 Distribution of patients according to lauge hensen Classification

Table 6 Distribution of patients according to AO/OTA classification

AO/OTA Classification	No. of cases	Percentage
44B1	2	11.8%
44B2	5	29.4%
44B3	4	23.5%
44C2	1	5.9%
44C3	5	29.4%
Total	17	100.0%

This table shows distribution of patients according to AO/OTA classification. Most of the patients have 44b2 , 44b3 and 44C3 type of ankle injury . type 44A injuries are the least common .

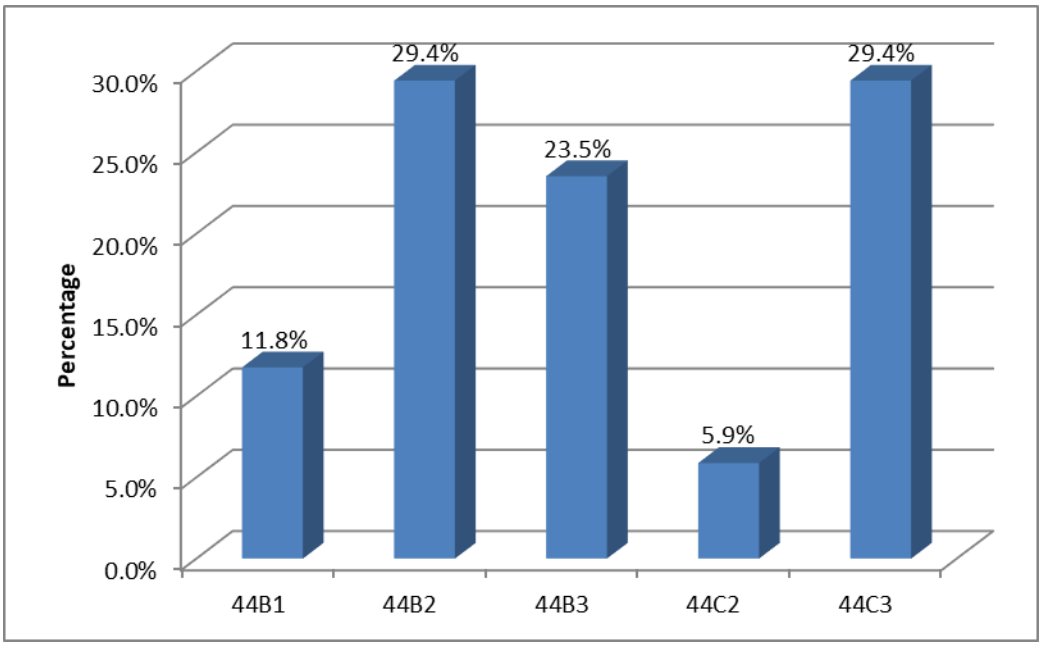


Figure 5 Distribution of patients according to AO/OTA classification

Table 7 Distribution of patients according to danis weber Classification

DANIS WEBER	No. of cases	Percentage
TYPE A	0	0 %
TYPE B	11	64.7%
TYPE C	6	35.3%
Total	17	100.0%

This table shows that most of the patients have type B and type C type of injury and none of the patients have type A type of ankle fracture . the type B injury corresponds with type 44b of AO classification and type C weber corresponds with type 44C of AO classification . 4 out of 11 patients of type B has been operated while 3 out of 6 patients of type C injury has been operated .

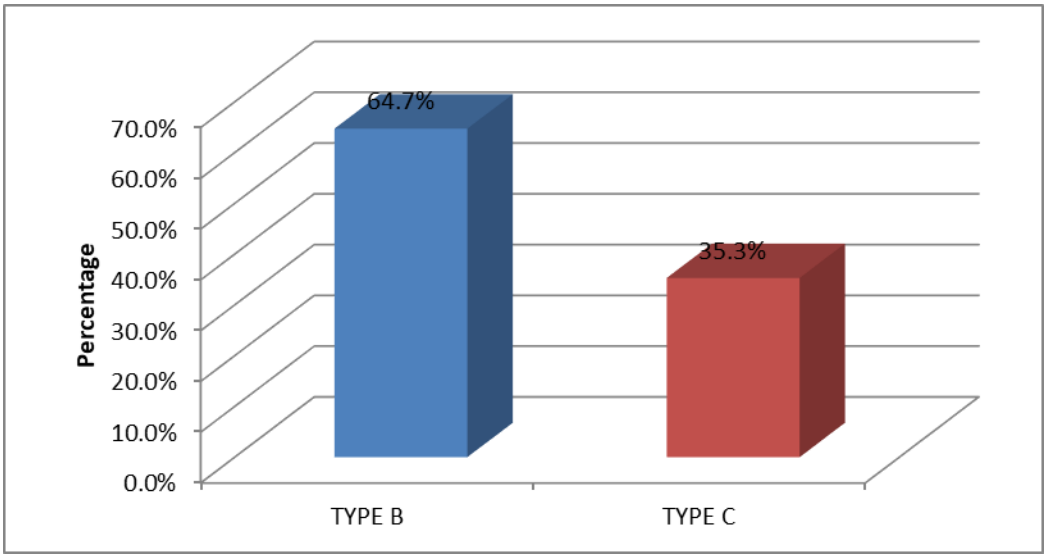


Figure 6 Distribution of patients according to danis weber Classification

Table 8 Distribution of patients according to method of fixation used for posterior malleolus

Fixation used for posterior malleolus	No. of cases	Percentage
NONE	10	58.8%
SCREW (PA)	4	23.5%
PLATE	3	17.6%
Total	17	100.0%

The table shows distribution of patients according to method of fixation . 10 patients were managed conservatively (58.8%). 4 patients (23.5%) were operated with posterior to anterior cancellous cannulated screws and 3 patients (17.6%) were operated with plate. This shows that different methods of fixation of posterior malleolar fragment are there and the method of fixation depends on various factors .

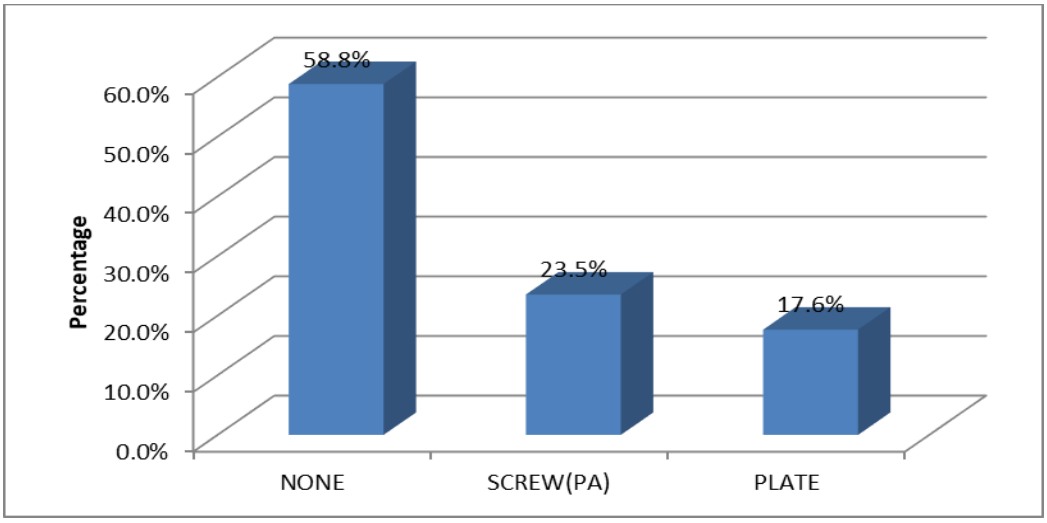


Figure 7 Distribution of patients according to method of fixation used for posterior malleolus

Table 9 Distribution of patients according to union time of fracture in weeks

Union time (weeks)	No. of cases	Percentage
< 6	0	0.0%
6-8.0	3	17.6%
8-10.0	10	58.8%
> 10	4	23.5%
Total	17	100.0%

This table shows distribution of patients according to time to union (in weeks). Fracture was termed radiologically united when bridging callus was present across the fracture site. It was observed that 82% of patients had their fracture United in between 8 to 12 weeks from the date of surgery.

Average time to union was 10.1 weeks with the range from 8 to 12 weeks. Therefore we can conclude that majority of ankle fractures involving the posterior malleolus unite by the end of 3 months as described in various other studies.

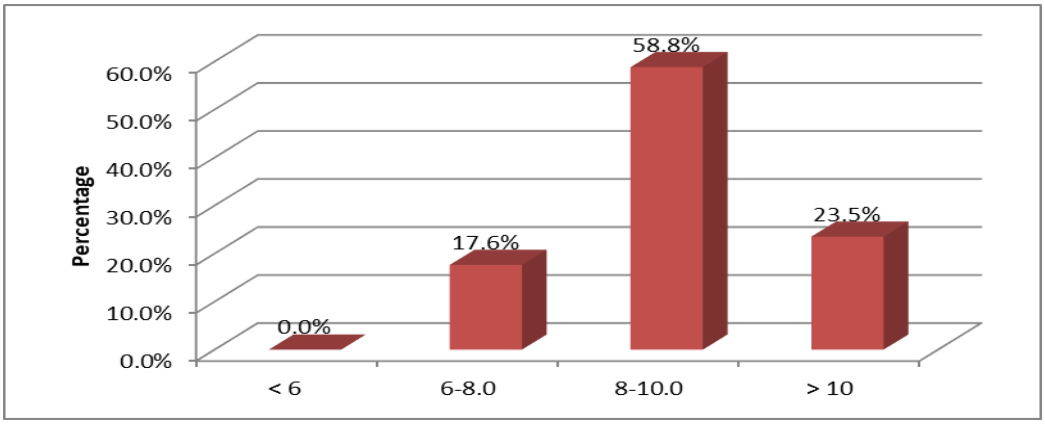


Figure 8 Distribution of patients according to union time of fracture in weeks

Table 10 Distribution of patients according to final AOFAS score at 24 weeks

FINAL AOFAS SCORE	No. of cases	Percentage
Poor < 50	0	0.0%
Accepatable 50-74	4	23.5%
Good 75-89	9	52.9%
Excellent > 90	4	23.5%
Total	17	100.0%

This table shows that more than half of the patients (76%) have a good to excellent final AOFAS score . (23.5%) patients have a accepatable AOFAS score. at the end of the study . this shows that majority of the patients have good to excellent AOFAS score treated by different methods of fixation . the most appropriate method depends on various factors of posterior malleolus anatomy .

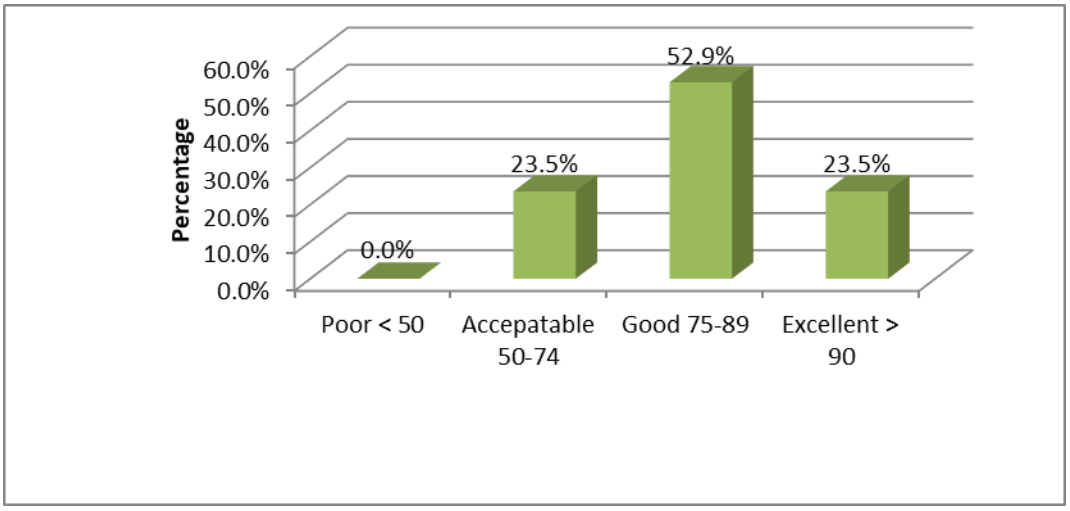


Figure 9 Distribution of patients according to final AOFAS score at 24 weeks

Table 11 Distribution of patients according to percentage of articular surface involved

% of articular surface involved	No. of cases	Percentage
< 10	0	0.0%
10-20.0	9	52.9%
20-30	5	29.4%
> 30	3	17.6%

This table shows that 52.9% of the patients have articular surface area involvement of 10-20% while 29.4% of patients have articular surface area involvement of >30% while .

Therefore we conclude that articular surface area involvement have significance in long term outcome of ankle fractures involving the posterior malleolus .

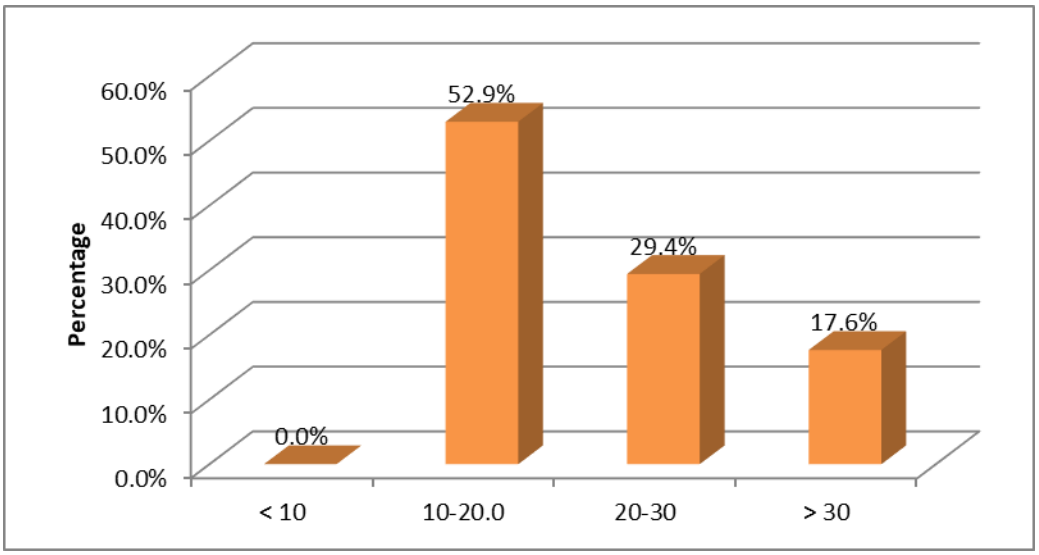


Figure 10 Distribution of patients according to percentage of articular surface involved

Table 12 Distribution of patients according to posterior subluxation preoperatively

posterior subluxation pre op	No. of cases	Percentage
NO	11	64.7%
YES	6	35.3%
Total	17	100.0%

This table shows that 64.7 % of patients have no subluxation on pre operative radiographs while 35.3 % have posterior subluxation preoperatively which was being corrected on post operative radiographs and it has also impact on long term outcomes of ankle fractures involving posterior malleolus .

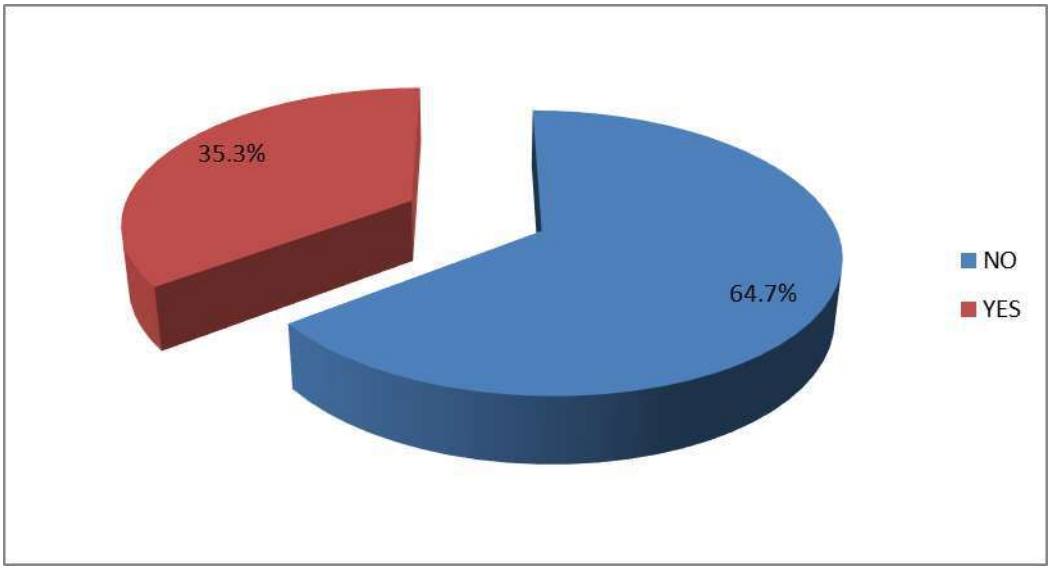


Figure 11 Distribution of patients according to posterior subluxation preoperatively

Table 13 Distribution of patients according to posterior subluxation postperatively

Malreduction /posterior subluxation post op	No. of cases	Percentage
NO	17	100.0%

Table 14 Distribution of patients according to secondary procedures done

secondary procedures	No. of cases	Percentage
NO	17	100.0%

This table shows that no secondary procedures have been done in our study

Table 15 Distribution of patients according to average age. Average time to union, average final AOFAS SCORE and average percentage of articular surface area involved

	N	Min	Max	Mean	Std. Deviation
AGE	17	27	75	52.18	15.785
Union time Radiological (weeks)	17	8	12	10.12	1.317
FINAL AOFAS SCORE	17	61	91	81.65	9.076
% of articular surface involved	17	10	50	22.06	10.871

This table shows that mean age in our study is 52.18 years which makes this fracture prevalent in old age population . mean time to union is 10.12 weeks with range from 8 to 12 weeks .the mean AOFAS score comes out to be 81.65 which is a good score according to grading . mean articular surface area involvement is 22.06% .

Table 16 comparison of patients according to lauge hensen classification with respect to final AOFAS score

		FINAL AOFAS SCORE						Total
		Accepatable 50-74		Good 75-89		Excellent > 90		
Classification of fracture_Lauge Hansen	PER	1	25.0%	5	55.6%	0	0.0%	6
	SER	3	75.0%	4	44.4%	4	100.0%	11
Total		4	100.0%	9	100.0%	4	100.0%	17

This table shows that patients with SER type of ankle injury have a good to excellent final AOFAS Score as compared to patients with PER type of ankle injury . therefore we conclude that type of ankle injury has some impact on final outcome .

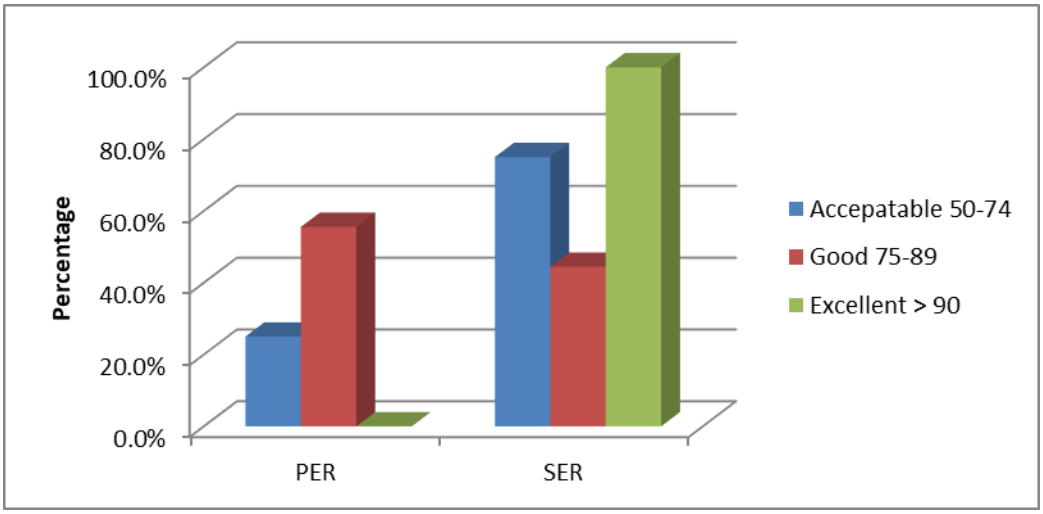


Figure 12 comparison of patients according to lauge hensen classification with respect to final AOFAS score

Table 17 Comparison of patients according to percentage of articular surface area involved with respect to final AOFAS score

		FINAL AOFAS SCORE						Total
		Acceptable 50-74		Good 75-89		Excellent > 90		
% of articular surface involved	10-20.0	1	25.0%	5	55.6%	2	50.0%	8
	20-30	1	25.0%	3	33.3%	2	50.0%	6
	> 30	2	50.0%	1	11.1%	0	0.0%	3
Total		4	100.0%	9	100.0%	4	100.0%	17

This table shows that majority of patients with 10-20% and 20-30% articular surface area involvement have a good to excellent final AOFAS score while majority of patients with >30% articular surface area involvement have a acceptable to good final AOFAS score . therefore we conclude thar posterior malleolar fragment size has some impact on functional outcome with need for fixation in larger fragments .

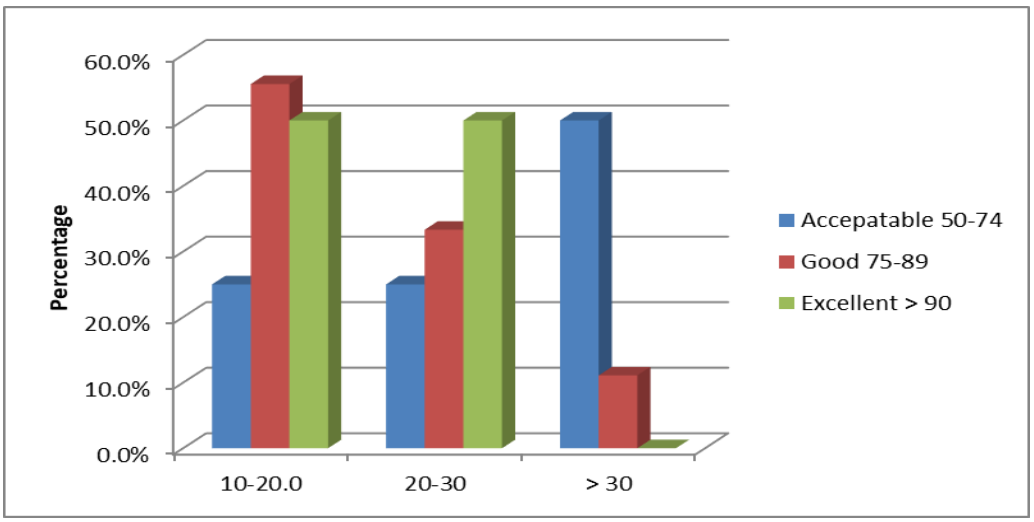


Figure 13 comparison of patients according to percentage of articular surface area involved with respect to final AOFAS score

Table 18 comparison of patients according to percentage of posterior subluxation of ankle with respect to final AOFAS score

		FINAL AOFAS SCORE						Total
		Accepatable 50-74		Good 75-89		Excellent > 90		
posterior subluxation pre op	NO	2	50.0%	5	55.6%	4	100.0 %	11
	YES	2	50.0%	4	44.4%	0	0.0%	6
Total		4	100.0%	9	100.0 %	4	100.0 %	17

this table shows that patients with excellent final AOFAS score had no posterior subluxation preoperatively while patients with good and accepatable final AOFAS score had posterior subluxation in approximately 50% of cases. the posterior subluxation was being corrected postoperatively which has a impact on functional outcome of ankle fractures involving the posterior malleolus.

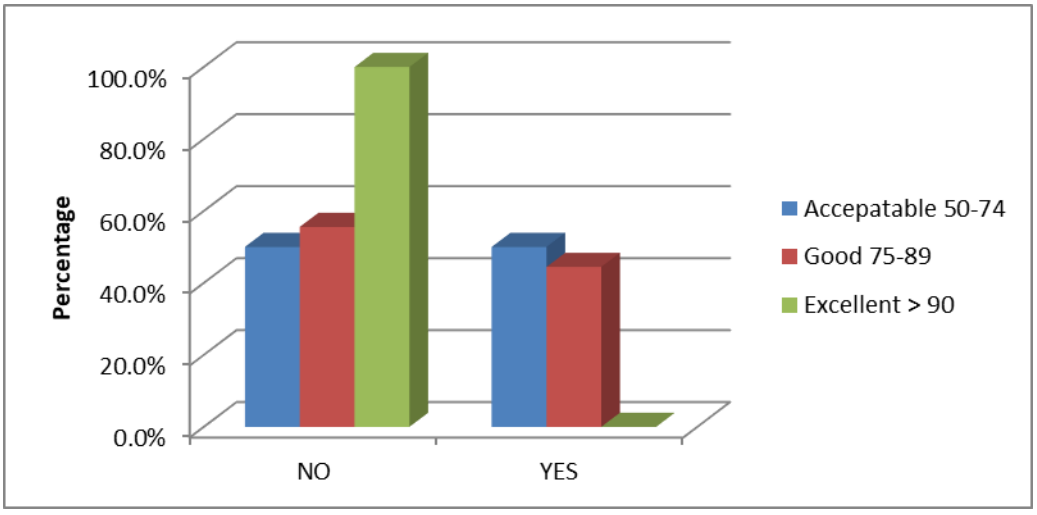


Figure 14 comparison of patients according to percentage of posterior subluxation of ankle with respect to final AOFAS score

Table 19 table showing distribution of complications in various patients

complications	No. of cases	Percentage
Non union	0	0%
Posttraumatic arthritis	1	5%
Total	17	100%

This table shows that no case of non union was reported at final follow up of 6 months. Fracture union was achieved in all the cases. While approximately 5% of patients developed post traumatic arthritis at the end of the study

.

DISCUSSION

Ankle fractures with a posterior malleolus fragment are a common injury, which open necessitates surgical fixation. Treatment of ankle fractures involving posterior malleolus has been a matter of debate and Management of posterior malleolus fractures present a major challenge in modern Orthopaeics as no fixed criteria is considered for decision of operative fixation of posterior malleolus. The factors relating to anatomy of ankle joint fragment size, ligamentous injury, articular congruity, talocrural and syndesmotic stability makes fracture management protocol individualized in every patient. Ankle is an important joint in lower limb as it plays a crucial role in weight bearing, foot movements. Therefore need for anatomical reduction is paramount in these fractures preventing ankle degenerative arthritis and other complications. Some authors have found no differences in clinical outcomes and ankle stability in PMF treatment based on posterior fixation, others have found that reduction and fixation performed on large fragments yields better results. Furthermore, non anatomical reduction of PMF leads to worse outcomes than non operative treatment. In recent years, there has been increased interest in fixing posterior malleolar fragments in view of it might reduce development of osteoarthritis, which would ultimately result in better functional outcome . in this study 17 patients with with ankle fracture involving the posterior malleolus were evaluated for functional outcome .

Table 20 Age and sex incidence

	Mean age	Average follow up
Our study	52.1 years	15.4 months
Veltman et al	46 years	42.4 months
Neuman et al	60 years	83.6 months
Mchale et al	56.2 years	16 months
Jeyaseelan et al	42 years	33.5 months
Tosun et al	47 years	15 months

Ewout s.veltman et al[53] in 2015 conducted a study in 985 patients in which mean age was 46 years in which 38% were male patients neumann et al[71] in 2021 conducted a study involving posterior malleoulus fractures in 100 patients with mean age of fracture was 60 years which included 40 % male patients and rest of female patients mchale et al[61] in 2019 conducted a study of ankle fractures involving the posterior malleolus in which mean age was found to be 56.2 years in which the male : female was 1:1 jeyaseelan et al[70] conducted a study for outcomes of posterior malleolus fixation in ankle fractures in which mean age was found to be 42 years in which 48 % were male patients tosun et al[63] conducted a study in which mean age was 47 years karaca et al[55] cOnducted a study on importance of fixation of posterior malleolar fracture in trimalleolar fractures in which mean age was 55.9 years in our study mean age was 52.1 years with range from 29 to 75 years 58.8 % were males and rest were female patients . These fractures are more common among the elderly population with associated comorbid conditions and age related osteoporosis and result after a domestic fall. Patients younger than 50 years of age often receive injury usually after a road traffic accident and they show significantly less rates of complications and better functional outcomes as compared to elderly population. We also conclude that ankle injuries involving posterior malleolus most commonly occurs in 4th to 7th decade particularly common in old age patients.

Table 21 Lauge Hansen Classification

	Supination ext. rotation	Pronation ext. rotation
Our study	64.7%	35.3%
Neuman et al	30%	24%
Mchale et al	75%	21%
Tosun ey al	67.3%	32.7%

neumann et al[71] in 2021 conducted a study involving posterior malleoulus fractures in which 30% patients have SER mechanism of injury and 24 % have PER type of injury and 46% pronation abduction type of injury mchale et al[61] in 2019 conducted a study of ankle fractures involving the posterior malleolus in which 75% patients have SER mechanism of injury and 21 % have PER type of injury and 4% were not classifiable tosun et al[63] conducted a study of ankle fractures involving the posterior malleolus in which 67.3% patients have SER mechanism of injury and 32.7 % have PER type of injury in our study 64.7% of patients have SER type of injury and rest of the patients have per type of injury

Table 22 Weber Classification

	WEBER TYPE B	WEBER TYPE C
OUR STUDY	64.7%	35.3%
NEUMAN et al	76%	24%
VELTMAN et al	67%	30%
HAI LIN XU et al	76%	22%

neumann et al[71] in 2021 conducted a study involving posterior malleoulus fractures in which weber type B fracture was found in 76% of patients and weber type C was found in 24% of patients.

Ewout s.veltman et al[53] in 2015 conducted a study in which weber type B fracture was found in 67% of patients and weber type C was found in 30% of patients and 3 % with weber type A injury.

Hailin xu et al[52] conducted a study in which weber type B fracture was found in 76% of patients and weber type C was found in 22% of patients and 2% with weber type A injury.

In our study we concluded that weber type B fracture was found in 64.7% of patients and weber type C was found in 35.3% of patients and no patients with type A fracture Therefore we conclude that both LAUGE

HANSEN AND WEBER classification systems grade Ankle injuries according to mechanism of forece and severity of injury . most of the patients suffer from SER TYPE OF ANKLE INJURIES and these injuries have overall have good functional outcome AOFAS score as compared to PER type of ankle injury . also type B weber injuries have good long term functional outcome as compared to type C WEBER injuries and this is also proved in previous literature . complications are most commonly associated with weber type C INJURIES . Mchale et al in their study concluded that PER type injuries is associated with significantly worse outcomes.

Mode of injury

Hailin xu et al[52] conducted a study in 102 patients in which 50 patients had ankle injury after domestic fall and 49 patients have injury after road traffic accident Karaca et al[55] found in their study that 60% of patients had injury of posterior malleolus after road traffic accident and 40 % had it after ground level fall.

In our study it was found that out of 17 patients 14 patients had ankle injury after road traffic accident and 3 had ankle injury after domestic fall.

THERFORE we conclude that presence of posterior malleolar fractures may indicate higher energy of injury, and it seem to result in worse outcomes if not dealt properly.

Table 23 Percentage of articular surface area involved

	Average articular surface area involved
Our study	22.06 %
Veltman et al	23.05 %
Mchale et al	20.08 %
Hai lin xu et al	19.01 %
Tosun et al	24.05 %
Karaca et al	21.06 %

Hailin xu et al[52] found that 6.3% patients have a fragment size of <10% , 59% patients have a fragment size of 10-25 % and 34.7% patients have a fragment size of >25% , and average posterior malleolus fragment size was 19.1 %.

mchale et al[61] in their study found that 45% patients have a fragment size of <10% , 24% patients have a fragment size of 10-20 % , 16% patients have a fragment size of 20-30 % , 15% patients have a fragment size of >30% with average fragment size of 20.8%.

Ewout s.veltman et al[53] in their study found that 17% patients have a fragment size of <10% , 66% patients have a fragment size of 10-33 % and 17% patients have a fragment size of >33% with average posterior malleolus fragment size was 23.5 %.

Tosun et al[63] found in their study average posterior malleolus fragment size was 24.5 % of the total articular surface area involved.

Karaca et al[55] found in their study average posterior malleolus fragment size was 21.06 % of the total articular surface area involved.

In our study we found that 0% patients have a fragment size of <10% , 52.9% patients have a fragment size of 10-20 % , 29.4% patients have a fragment size of 20-30 % , 17.6% patients have a fragment size of >30%, average posterior malleolus fragment size was 22.06 % .

So we concluded in our study that increasing posterior malleolus size is associated with poorer clinical outcomes . the worse outcomes are seen with posterior malleolus size 10-20% because this group was mostly treated without direct fixation of posterior malleolar fragment . the best scores were in <10 % without direct fixation and >20% group with direct fixation. as patients who underwent direct fixation had a higher rate of anatomic reduction , the difference in fixation may explain the better outcomes.

Numerous authors prescribe restoring to posterior malleolar stabilization with internal fixation when fragment size involves >25% of articular surface

area. in patients with articular size area <10% rigid fixation of lateral malleolus yield a near anatomic reduction of the posterior malleolus.

Table 24 Method of fixation

	AP SCREW	PA SCREW	PLATE FIXATION
Our study	0%	23.5%	17.6%
Neumann et al	14%	13%	36%
Karaca et al	19%	61%	20%
Mchale et al	0 %	4%	29.3%
Tosun et al	0%	45%	55%
Jeyaseelan et al	2%	10%	38%

neumann et al[71] in their study managed 37% percent of posterior malleolus fractures conservatively, in 14% of patients AP screw fixation was done, In 13% of patients PA screw fixation was done and 36% of patients were managed with plate karaca et al[55] in their study evaluated 57 patients in their study which were treated operatively out of which 19% patients managed with AP screws and 61% patients managed with PA screws and 20 % managed with plate fixation.

mchale et al[61] in their study managed 66.7% percent of posterior malleolus fractures conservatively, in 0% of patients AP screw fixation was done, In 4% of patients PA screw fixation was done and 29.3% of patients were managed with plate tosun et al[63] conducted a study in which out of operated patients 45% patients had undergone a PA screw fixation while 55% were treated with plate fixation.

jeyaseelan et al[70] intheir study managed 50% percent of posterior malleolus fractures conservatively , in 2% of patients AP screw fixation was done , In 10% of patients PA screw fixation was done and 38% of patients were managed with plate in our study we managed 58.8% percent of posterior malleolus fractures conservatively , in 0% of patients

AP screw fixation was done , In 23.5% of patients PA screw fixation was done and 17.6% of patients were managed with plate it has been described in literature that, anatomical reduction of the posterior malleolar fragment to restore the articular surface and the normal anatomy of the inferior tibiofibular joint is must for good outcomes. As per literature AP screw fixation is simple, convenient in removal but is less preferred because it is difficult to reach firm pressurization with it. While the PA screw has sound pressurization effect. Also in study conducted via HAI LIN XU et al in AP screw fixation, reduction was affected because the screw thread appeared in fracture line. While PA screw achieved anatomical reduction.

Our preferred method of fixation for ankle fractures involving the posterior malleolus is fixation of lateral malleolus along with posterior malleolus through a posterolateral approach regardless of fragment size. The posterolateral approach provides a real internervous palne between flexor hallucis longus tendon and peroneal muscles.

Table 25 Final AOFAS score

	FINAL AOFAS SCORE
OUR STUDY	81.65
Hai lin xu et al	92.2
Neumann et al	87.5
Veltman et al	74
Tosun et al	92
Karaca et al	88

Hailin xu et al[52] found in their study the average final AOFAS score was 92.2 neumann et al[71] in their study the average final AOFAS score was 87.5 Ewout s.veltman et al[53] in their study found the average final AOFAS score was 74 Tosun et al[63] in their study showed that patients who had

undergone fixation for posterior malleolus had average final AOFAS score of 92 as compared to 70 in non-operated patients.

Karaca et al[55] in their study found that 21 out of 26 patients had good to excellent final AOFAS score with average final score was 88.

In our study we found the average final AOFAS score to be 81.65

We used the AOFAS score as our outcome measurements, because it is the most coomonly used score and allows some comparison with other studies. In our study 11 out of 17 patients had good to excellent final AOFAS score at the end of the study . therefore we conclude that 6 patients with articular surface area of >20% has been operated to achieve direct anatomical reduction and 5 out of that 6 patients have good to excellent final AOFAS score .

Posterior subluxation

Mchale et al[61] in their study found that 42.7 % of ankle fractures had a posterior subluxation on initial radiographs in our study we found that 35.3% % of ankle fractures had a posterior subluxation on initial radiographs mchale et al in their study concluded that posterior subluxation was associated with a significantly higher rate of total complications and a higher rate of secondary surgery. also in our study we concluded that posterior subluxation on initial radiographs denote a high energy trauma and it is associated with larger size of posterior malleolar fragment and need for anatomical reduction is mandotary in these cases .

Table 26 Time to union

	Time to union (weeks)
Our study	10-12 weeks
Hai lin xu et al	12 weeks
Tosun et al	12 weeks
Karaca et al	12 weeks

tosun et al[63] conducted a study in which they concluded that fracture healed with in 12 weeks in all the patients .

hailin xu et al[52] in their study found that clinical union of fracture was achieved within 12 weeks in all the patients .

Karaca et al[55] in their study found that clinical union of fracture was achieved within 12 weeks in all the patients .

in our study we found average time to union is 10.12 weeks with range from 10-12 weeks therefore we conclude that all the ankle fractures involving the posterior malleolus usually unites with in a period of 12 weeks if ankle joint stability has been maintained . All posterior malleolus fracture fragments in our study united with in period of 12 weeks which is comparable with other studies with a good to excellent final AOFAS score

Final range of motion

karaca et al[55] average final dorsiflexion at end of our study is 18.9 with range from 10-25 degrees and average final plantarflexion at end of our study is 38.6 with range from 33 – 45 degrees .

In our study we found that average final dorsiflexion at end of our study is 28.82 with range from 20-30 degrees and average final plantarflexion at end of our study is 38.53 with range from 30 – 45 degrees.

We conclude from our study that patients with articular size <10% have a good range of motion at ankle joint when treated conservatively. While patients with articular size >20% have a good range of motion at ankle joint when treated operatively and joint congruency is maintained.

Complications

Ewout s.veltman et al[53] in their study found that only 2% of patients have non –union and 2% patients have posttraumatic osteoarthritis after a mean follow up of 44 months after surgery

tosun et al[63] conducted a study in which they concluded that no patient had nonunion at the end of the study

karaca et al[55] conducted a study in which they concluded that no patient had nonunion at the end of the study

hailin xu et al[52] found that no patient had non union while patients has developed posttraumatic osteoarthritis in which articular size was > 25%.
jeyaseelan et al[70] in their study conclude that only 2.5% patients had posttraumatic osteoarthritis of ankle joint and it was higher in unfixed group of patients .
In our study we found that no patient had non union while 5% patients has developed posttraumatic osteoarthritis which is comparable with other studies in literature. Karaca et[55] al in their study found higher incidence of post traumatic osteoarthritis among patients with posterior fragments involving the tibial plafond (>30%) than in fractures with small posterior fragments or no posterior fragments . In our study we believe that low incidence of osteoarthritis is caused by the fact that symptoms and radiological signs of this common complication of osteoarthritis take several years to develop and thus not evident.

SUMMARY

This is a study evaluating functional outcome in Ankle fractures involving the posterior malleolus performed on 17 patients followed up to 6 months.

- 70% of the patients were above the age of 40 years with equal male to female ratio with Average follow up of 15.4 months.
- Road traffic accidents was the main mode of injury among the patients.
- More than half of the patients had SER type of ankle fracture according to Lauge Hansen classification.
- 80% of the patients were categorised having Type 44B or type 44C fracture as per AO/OTA classification.
- 65% of the patients have Weber Type B while rest have Type C injury.
- It is critical to have anatomical reduction of PM fragment regardless of size of the fragment as well as method employed to obtain the reduction – whether indirect by reduction of lateral malleolus or by direct exposure and fixation of PM fragment in order to get satisfactory results.
- Posterior malleolar stabilization is desirable with internal fixation especially when fragment size is >25 % articular surface area.
- Approach is dictated by the location of Posterior fragment. Usually the fragment is posterolateral so Posterolateral approach is preferred with direct visualization of PM fragment and fixation with screw or plate.
- Fracture united between 8 to 12 weeks in 100% of the patients with average union time of 10.12 weeks.
- About 65% of the patients had good to excellent results 6 months after the procedure with an average AOFAS score of 81.65.
- No patient had poor result as per AOFAS score.
- Posterior subluxation is associated with significant higher complications.
- No incidence of secondary loss of reduction, non-union, malunion.
- 5 % of patients developed post-traumatic arthritis on final radiographs.
- This study has some limitations due to its relatively small number of patients.

CONCLUSION

Treatment of ankle fractures involving posterior malleolus has been source of intense debate over last several decades. Both non operative and surgical treatments have been purposed but factors such as Fragment size, Ankle joint congruity, Talocrural and Syndesmotic stability have been taken into account for optimal treatment of Posterior malleolar fragment. Posterior malleolus is an important structure of distal tibiofibular joint, as it provides osseous restraint for distal fibula as well as syndesmosis through posterior inferior tibiofibular ligament and inferior transverse ligament.

It is critical to have anatomical reduction of PM fragment regardless of size of the fragment as well as method employed to obtain the reduction – whether indirect by reduction of lateral malleolus or by direct exposure and fixation of PM fragment in order to get satisfactory results.

Union of fracture is achieved in all patients within 12 weeks with only 5 % showing post traumatic arthritis on final radiographs. Anatomical reduction, stable fixation of all PM fragment and post-operative physiotherapy regimen are the most important factors in improving the final functional outcome in patients of ankle fractures involving the Posterior malleolus treated with different methods.

We conclude that ankle fractures with a Posterior malleolar fragment are complex, high energy injuries which often necessitates surgical fixation and the appropriate treatment depends on various factors.

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PATIENT 1 AS PER MASTER CHART

Preoperative X-ray

Pre operative CT scan

Post operative xray

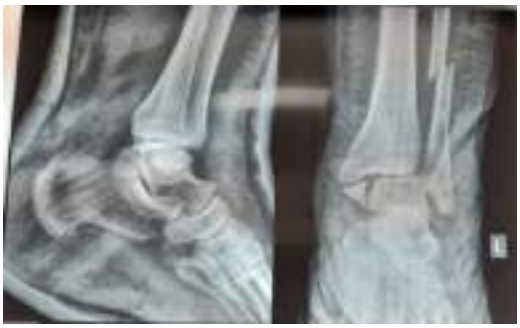
follow up after 4 weeks

follow up after 12 weeks

Follow up after 24 weeks

Clinical outcome after 6 months

PATIENT 4 AS PER MASTER CHART



Preoperative X-ray

Post operative X-ray

Follow up after 12 weeks

Follow up after 24 weeks

Clinical outcome after 6 months

PATIENT 6 AS PER MASTER CHART

Preoperative X-ray

Post operative X-ray

Follow up after 4 weeks

follow up after 24 weeks
With post traumatic arthritis

Clinical outcome after 6 months

PATIENT 7 AS PER MASTER CHART

Pre operative CT scan

Preoperative X-ray

Immediate post op after Ex fix application

Immediate post op after ORIF

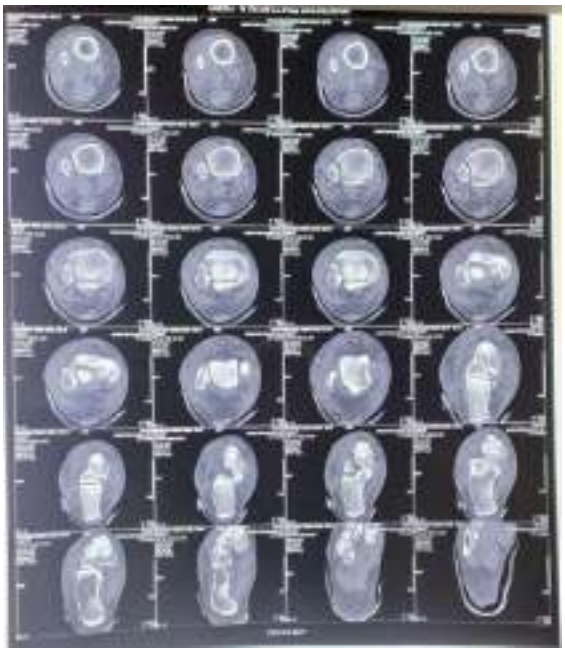
Follow up after 4 weeks

Follow up after 12 weeks

follow up after 24 week

Clinical outcome after 6 months

PATIENT 14 AS PER MASTER CHART



Pre operative Xrays & CT scan

Post-operative X-ray

Follow up after 12 weeks

Follow up after 24 weeks

Clinical outcome after 6 months

Sr. No	MRD No.	NAME	AGE	SEX	Mode of injury	Type of fracture	Classification of fracture			External Fixator application	Fixation used for posterior malleolus
							Lauge Hansen	DANIS WEBER	AO/OTA Classification		
1	491749	MG	37	F	FALL	CLOSED	SER	TYPE B	44B1	NO	BELOW KNEE SLAB
2	868594	KB	29	M	RTA	CLOSED	PER	TYPE C	44C3	YES	BELOW KNEE SLAB
3	880096	SA	50	F	RTA	CLOSED	PER	TYPE C	44C3	YES	T PLATE + B/K SLAB
4	894452	VA	55	M	RTA	CLOSED	PER	TYPE C	44C3	NO	1 4.5 MM CCS +B/K SLAB
5	324738	KD	72	F	RTA	CLOSED	SER	TYPE B	44B2	NO	B/K SLAB
6	141370	MRG	68	M	FALL	CLOSED	SER	TYPE B	44B2	NO	B/K SLAB
7	926138	SJ	69	M	RTA	OPEN	SER	TYPE B	44B2	YES	1 4.5 MM CCS + B/K SLAB
8	937147	AK	64	M	RTA	CLOSED	SER	TYPE B	44B2	YES	1 4.5 MM CCS + B/K SLAB
9	940362	KK	53	F	RTA	CLOSED	PER	TYPE C	44C3	YES	2 4.5 MM CCS + B/K SLAB
10	205001	RS	55	M	RTA	CLOSED	SER	TYPE B	44B3	NO	B/K SLAB
11	814499	KR	75	M	FALL	OPEN	SER	TYPE B	44B1	YES	EX FIX APPLICATION
12	1065140	PS	27	M	RTA	CLOSED	PER	TYPE C	44C2	NO	B/K SLAB
13	1094481	MP	35	F	RTA	CLOSED	SER	TYPE B	44B3	NO	B/K SLAB
14	1090447	MS	52	M	RTA	CLOSED	SER	TYPEB	44B3	NO	I RC PLATE + B/K SLAB
15	1123838	BS	69	M	RTA	CLOSED	SER	TYPE B	44B2	NO	T PLATE + B/K SLAB
16	1137312	AN	35	F	RTA	CLOSED	SER	TYPE B	44B3	NO	B/K SLAB
17	1142391	MJ	42	F	RTA	CLOSED	PER	TYPE C	44C3	YES	B/K SLAB

Approach used for posterior malleolus fixation	Fixation for medial mallelolar fracture and approach	Fixation for lateral mallelolar fracture and approach	Immobilisation done	Physiotherapy			Complicat	
				Range of motion	Partial weight bearing	Full weight bearing	1. Intra-operative	2. Immediate Post-operative
NO	NO	NO	YES	5 DAYS	4 WEEKS	6 WEEKS	NO	NO
NO	2 K WIRES	1 RC PLATE	YES	5 DAYS	6 WEEKS	8 WEEKS	NO	NO
POSTEROLATERAL	2 CCS	1 RC PLATE	YES	5 DAYS	6 WEEKS	12WEEKS	NO	NO
POSTERIOR TO ANTERIOR	2 CCS	1 RC PLATE	YES	2 DAYS	8 WEEKS	10 WEEKS	NO	NO
NO	2 CCS	1/3 TUB. PLATE	YES	4 DAYS	6 WEEKS	10 WEEKS	NO	NO
NO	NO	1 RC PLATE	YES	3 DAYS	6 WEEKS	8 WEEKS	NO	NO
POSTERIOR TO ANTERIOR	NO	1 RC PLATE	YES	5 DAYS	6 WEEKS	10 WEEKS	NO	NO
POSTERIOR TO ANTERIOR	NO	1 RC PLATE	YES	3 DAYS	6 WEEKS	10 WEEKS	NO	NO
POSTERIOR TO ANTERIOR	3 CCS	1/3 TUB.PLATE	YES	5 DAYS	6 WEEKS	8 WEEKS	NO	NO
NO	2 CCS	1 RC PLATE	YES	5 DAYS	4 WEEKS	8 WEEKS	NO	NO
NO	NO	NO	YES	7 DAYS	6 WEEKS	12 WEEKS	NO	NO
NO	NO	1 RC PLATE	YES	5 DAYS	6 WEEKS	10 WEEKS	NO	NO
NO	1 CCS	1 RC PLATE	YES	4 DAYS	6 WEEKS	12 WEEKS	NO	NO
POSTEROLATERAL	1 CCS	1 RC PLATE	YES	7 DAYS	6 WEEKS	12 WEEKS	NO	NO
POSTEROLATERAL	NO	1 RC PLATE	YES	5 DAYS	8 WEEKS	12 WEEKS	NO	NO
NO	3 CCS	1/3TUB. PLATE	YES	5 DAYS	8 WEEKS	12 WEEKS	NO	NO
NO	1 CCS	1 RC PLATE	YES	3 DAYS	6 WEEKS	10 WEEKS	NO	NO

ions	FINAL			TIME TO UNION (WEEKS)	FINAL AOFAS SCORE	% of articular surface involved	posterior subluxation		SECONDARY PRECEDURES
3. Late Post-operative	X ray findings	Dorsi flexion at ankle joint	Plantar flexion at ankle joint				pre op	post op	
NO	UNITED	0-30	0-35	8	85	13	NO	NO	NO
NO	UNITED	0-30	0-40	10	87	10	YES	NO	NO
NO	UNITED	0-25	0-35	12	85	50	YES	NO	NO
NO	UNITED	0-30	0-45	8	85	25	NO	NO	NO
NO	UNITED	0-25	0-40	10	87	16	YES	NO	NO
NO	UNITED	0-30	0-35	10	90	10	NO	NO	NO
POST-OP ARTHRITIS	UNITED	0-30	0-40	12	73	29	YES	NO	NO
POST-OP ARTHRITIS	UNITED	0-30	0-40	10	61	13	NO	NO	NO
NO	UNITED	0-30	0-40	8	64	33	NO	NO	NO
NO	UNITED	0-25	0-35	12	90	22	NO	NO	NO
NO	UNITED	0-30	0-40	12	79	16	NO	NO	NO
NO	UNITED	0-20	0-40	10	77	18	NO	NO	NO
NO	UNITED	0-30	0-35	8	83	20	NO	NO	NO
NO	UNITED	0-30	0-40	8	74	35	YES	NO	NO
NO	UNITED	0-25	0-45	10	91	30	NO	NO	NO
NO	UNITED	0-30	0-35	10	90	10	NO	NO	NO
NO	UNITED	0-25	0-35	8	87	25	YES	NO	NO

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Date 27/1/2021

The Principal,
DMC,Ludhiana.

Subject: **Approval of Plan of Thesis.**

This is to inform you that the Faculty of Medical Sciences in its meeting held on 22.01.2021 has approved the plan of thesis of **Dr. ahil Singla,** a student of your college for **MS Orthopaedics** along with the names of Supervisor/Co-Supervisor as under:-

Topic Plan of Thesis
Functional outcome of ankle fractures associated with fracture of posterior malleolus

Supervisor
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Co-Supervisor
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The student has to submit the three copies of thesis (along with PDF format) , to the Controller of Examinations, BFUHS, Faridkot, at least six months before the commencement of theory examination, if he/she is otherwise eligible to take the examination. He /She must directed to attach a photocopy of this letter with the forwarding letter while submitting thesis to the University along with the letter of approval of University for change of supervisor/Co-Supervisor, change of topic,(if any).

Dr. S P Singh MS(Oph)
Controller of Examinations

Note :

1. ***If any discrepancy found regarding topic of thesis or Supervisor/Co-Supervisor, inform undersigned within one month after issue of this letter.***
2. *The student may submit the thesis as per the schedule already conveyed i.e for May/June examination 30th Nov of the preceeding the year of examination and for Nov/Dec examinations 31st May of the year of examination.*

FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS

THESIS PROPOSAL

FOR APPROVAL OF SUBJECT OF THESIS TO BE SUBMITTED

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF SURGERY

IN

ORTHOPAEDICS

OF THE

BABA FARID UNIVERSITY OF HEALTH SCIENCES

FARIDKOT

SEPTEMBER, 2019

DR. SAHIL SINGLA

DEPARTMENT OF ORTHOPAEDICS

DAYANAND MEDICAL COLLEGE & HOSPITAL

LUDHIANA

ABSTRACT OF PLAN OF THESIS

Title	FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS
For the degree of	MS ORTHOPAEDICS
Name of the candidate	Dr. Sahil Singla
Supervisor	Dr. Deepak Jain, Professor, Department of Orthopaedics, DMCH, Ludhiana
Co-supervisors	Dr. Harpal Singh Selhi , Professor, Department of Orthopaedics, DMCH, Ludhiana
Institution	Dayanand Medical College & Hospital, Ludhiana
University	Baba Farid University of Health Sciences, Faridkot

Introduction: Ankle injuries gain importance because body weight is transmitted through it and locomotion depends upon the stability of this joint. Malleolar fractures are one of the most common fractures in orthopaedic traumatology. When malleolar fractures are not reduced accurately, that may lead to post traumatic restriction of motion or osteoarthritis or both. The indication for surgery for posterior malleolus fracture (PMF) is a subject of controversy and needs further study

Aim: To analyse the functional outcome of ankle fractures associated with fracture of posterior malleolus.

Material & Methods: This study is a retrospective and prospective study of patients with posterior malleolus fractures treated at our hospital.

Clinical Significance: To analyse the functional outcome of posterior malleolus fractures treated conservatively or operatively and devise a suitable treatment algorithm.

Keywords: PMF : Postero malleolus fracture, conservative, surgical.

(Signature)	(Signature)	(Signature)	(Signature)
Candidate	Co-supervisor	Supervisor	Principal

CERTIFICATE OF FACILITIES AVAILABLE

This is to certify that the facilities for work on the subject of thesis titled **"FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS"** exist in the Department of Orthopaedics, DMC&H, Ludhiana, and will be provided to the candidate. We will see that the data being included in the thesis are genuine and is collected by the candidate himself under our supervision and guidance.

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Date:

APPROVAL PROFORMA
BY RESEARCH & ETHICAL COMMITTEE
DAYANAND MEDICAL COLLEGE & HOSPITAL, LUDHIANA

Name of candidate	Dr Sahil Singla
Department	ORTHOPAEDICS
Topic of Thesis	FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS
Likely date of appearing in PG examination	JUNE 2022
Date of enrollment	th May, 2018
Name of Head of Department	Dr. Rajnish Garg
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Signature of Members of Research Committee with Stamp	**Signature of Members of Ethics Committee with Stamp**
Dr. Jaspal Singh (Professor & Head, Surgery)	Mr. A K Jindal (Member, Ethics Committee)
Dr. Dinesh Gupta (Professor & Head, Medicine)	Dr. Anu Sharma (Professor, Anatomy)
Dr. Sandeep Kaushal (Assistant Dean Academics)	Dr. Deepinder K Chhina (Professor & Head, Microbiology)
Dr. Rajoo Singh Chhina (Dean Academics)	Dr. Neena Sood (Professor & Head, Pathology)
Dr. Gurpreet S Wander (Vice Principal)	Dr. Gurpreet S Wander (Vice Principal)
	Dr. Gagandeep Singh (Secretary, Ethics Committee Professor & Head, Neurology)

Approved: Yes / ~~No~~

Dr. Sandeep Puri
Chairperson
Research Committee

Chairperson
Research Committee

Approved: Yes / ~~No~~

Prof. Arvind Malhotra
Chairperson
Ethics Committee

Chairperson
Ethics Committee

BABA FARID UNIVERSITY OF HEALTH SCIENCES, FARIDKOT

PROFORMA FOR REGISTRATION OF SUBJECT FOR DISSERTATION

1	NAME OF THE CANDIDATE AND ADDRESS	DR SAHIL SINGLA MUHALLA DHUNDEAN DA, WARD NO 4, BHADAUR , BARNALA, PUNJAB
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3	COURSE OF STUDY AND SUBJECT	MASTER OF SURGERY, ORTHOPAEDICS
4	DATE OF ADMISSION OF COURSE	MAY, 2018
5	TITLE OF THE TOPIC	FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS

6. BRIEF RESUME OF INTENDED WORK:

6.1 NEED FOR STUDY

Sir Robert jones said "Ankle is the most injured joint of the body but the least well treated". Ankle injuries gain importance because body weight is transmitted through it and locomotion depends upon the stability of this joint. Malleolar fractures have varied presentations which have given rise to wide variety of classification systems of which two are: Lauge-Hansens and Danis- weber classification.

Malleolar fractures are one of the most common fractures in orthopaedic traumatology. Approximately 7 to 44 % of ankle joint fractures are accompained by posterior malleolus fractures. Unimalleolar fractures are the most frequent followed by bimalleolar, then trimalleolar fractures. Isolated posterior malleolar fractures have been rarely reported, and are generally associated with other injuries around the ankle joint. While many authors have found that the presence of a posterior malleolar fracture is associated with poor outcomes, others have found poorer outcomes only in the short term and others have not found any predictive value in terms of functional outcome or late osteoarthritis.

Stabilisation of ankle fractures with PMF continues to be a subject of interest to the scientific community.[1] As with all intra-articular fractures, malleolar fracture necessitate accurate reduction and stable internal fixation. When malleolar fractures are not reduced accurately, that may lead to post traumatic restriction of motion or osteoarthritis or both. Many of the fractures which are stable are reduced by conservative treatment and have given good results. The indication for surgery in a case of a PMF is the subject of controversy. Since a study from 1940, it has generally been accepted that a PMF in a trimalleolar fracture should be internally fixated when the size of the fragment exceeds 33% of the joint surface or, according to several other authors, if the fragment exceeds more than 25%.[2,3]

Many studies can be found in the literature that retrospectively examined patients, but comparisons are difficult because of different examination methods.

Epidemiologic studies show a 34% higher risk for a posttraumatic arthrosis in trimalleolar fractures compared with bimalleolar ones.[2] It Is generally accepted that outcomes for patients with trimalleolar fractures compared with bimalleolar fractures are worse.[4,5]

The reasons for these results are not clear. Whether it is malreduction, instability, cartilage damage or peak pressure shift in the ankle joint remains unresolved.[5-7]

The clinical studies published in the current literature differ substantially from one other. Whereas Harper et al.[7] found that there was no difference regarding whether the fragment was internally fixated for patients with a PMF greater than 25%, Jaskulka et al. stated that a great posterior fragment should always be fixated for improved patient outcomes.

There has been an improvement in understanding of these fractures with an increasing trend to surgically treat posterior malleolus fracture. There is a need to study the functional outcome of fracture posterior malleolus treated conservatively or with internal fixation, hence this study.

6.2 REVIEW OF LITERATURE

Malleolar fractures are one of the most common fractures in orthopaedic traumatology. Approximately 7 to 44 % of ankle joint fractures are accompained by posterior malleolus fractures. Unimalleolar fractures are the most frequent followed by bimalleolar, then trimalleolar fractures.

Haraguchi et al classified PMFs into 3 types. Type 1 includes posterolateral-oblique fractures with triangular involvement of the posterolateral corner of the tibial plafond. This occurred in 67% of cases and the average size occupied 11.7% of the total joint area. Type 2 are medial extension fractures with extension of the fracture line to the anterior part of the medial malleolus. This occurred in 19% of cases and the average size occupied 29.8% of the total joint area. Type 3 are small-shell fractures at the posterior lip of the tibial plafond. This occurred in 14% of cases and the average size occupied. Type 1 PMFs were most appropriate for our study purposes. Type 2 PMFs were excluded because the relationship between ankle stability and PMF screw fixation is unclear. Type 3 PMFs were also excluded due to difficulty in screw fixation and small-sized fragments unrelated to the PITFL Mangnus et al showed that a PMF can occur in various directions, and the involved fracture line location may affect stability more than fracture surface size. Even with small PMFs, nonfunctioning posterior-inferior tibio-fibular ligaments (PITFLs) can affect the results.[8]

Bartoniček et al used more advanced CT reconstructions to classify posterior malleolus fractures in 141 patients. Their system has four main types. They emphasise the importance of recognising fractures that involve the incisura, since accurate reduction will facilitate. The reduction and stability of the syndesmosis.[9] As with the Haraguchi system, there is relevance to the choice of incision. In particular, the identification of a postero-medial fragment or the presence of any intercalated fragment is useful for surgical planning.

Macko et al. found that measurement on the lateral x-ray significantly underestimated the size of the fragment due to the obliquity of the fracture to the x-ray beam whilst Ferries found both underestimation and overestimation of fracture size on lateral x-rays when compared with CT findings.[10]

Erdem et al reported that screw fixation and buttress plate fixation had similar results after the posterolateral approach and reduction.[11]

Gardner et al8 confirmed on postoperative CT scans that PMF influences distal tibio-fibular ligament stability. The non fixed posterior malleolus can contribute subluxation of the tibio-fibular articulation. Rotation is a well-known mechanism for the occurrence of PMFs. Rotation induces PITFL avulsion force leading to PMF. Magnetic resonance imaging has demonstrated preservation of distal tibiofibular ligament integrity in PMFs of the ankle fractures. Previous studies focused on talar subluxation and articular surface effects, suggesting a 25% cutoff for PMF fixation.[12]

Recently, treatment for PMF has been debated as studies have demonstrated the effects of all-sized PMFs on ankle stability and surgical indications have expanded.23 Criteria considering size alone underestimate the number of fractures requiring surgery. Failure to fix a mal-reduced posterior malleolus could result in late posterolateral fibular subluxation and instability. Failure to restore congruity of the articular surface within 2 mm, including the posterior malleolus, is associated with worse functional outcomes at 1 year compared with patients whose congruity is restored.1,33 A significant incidence of radiographic arthritis occurs with step-offs of >2 mm at the posterior malleolus, regardless of fragment size. Congruity with stability and degree of reduction may be important prognostic factors, along with joint surface involvement.

Langenhuijsen et al reported that the amount of reduction and congruity with stability are important even with small posterior articular surfaces.[13]

McDanieland Wilson found better clinical and radiographic results were achieved when patients with fractures involving over 25%of the joint surface were managed operatively in their small series of 15 cases. This may relate to the inability to achieve anatomical reduction in any of their conservatively treated cases, with residual posterior subluxation in half of these.[14]

Harper and Hardin retrospectively reviewed 38 patients with posterior malleolar fractures also involving over 25% of the joint surface and found that the outcomes (includingreduction, union, complications, and late osteoarthritis) for operative and nonoperative management were the same.[15] Furthermore, Donken et al. reviewed 19 patients 20 years after an apparently isolated posterior malleolar fracture treated nonoperatively, and reported uniformly good subjective, objective, and radiographic results. As a result surgical practice is varied with some surgeons fixing all fractures involving greater than 25% of the joint surface and others citing ankle stability as the key in their decision making. The interpretation of these studies, and clinical decision making in individual cases, is made considerably more difficult because the ability to define the size of the posterior fragment based purely on plain radiographs has been shown to be prone to error.[16]

Verhage et al reviewed posterior fragments involving the intraarticular surface need to be reduced and fixated to prevent postoperative osteoarthritis.[17]

Kang C et al reviewed that screw fixation of PMFs was affective for fracture healing and maintaining the ankle alignment.[18]

6.3 AIMS AND OBJECTIVES OF THE STUDY

To study the functional outcome of ankle fractures associated with fracture of posterior malleolus.

7.0 MATERIALS AND METHODS

7.1 SOURCE OF DATA

The purpose of study is "To study the functional outcome of ankle fractures associated with fracture of posterior malleolus". This will be a retrospective and prospective study of cases of ankle fractures involving posterior malleolus treated between 1st Dec 2019 to Aug 2021 (Including 6 month Followup) at Dayanand Medical College, Ludhiana. Patients will be assessed at final follow up using "AOFAS "SCORE (American Orthopaedic Foot And Ankle Society)"

7.2 METHOD OF COLLECTION OF DATA

After obtaining approval from the institutional ethical committee, patients will be enrolled in the study on the basis of inclusion / exclusion criteria. The study will be carried out by taking an informed consent from the patients willing to be a part of the study.

Collection of data of patients presenting with ankle fractures with involvement of posterior malleolus will be as follows

- History
- Clinical examination both systemic and local
- Radiological examination using Xray (ANTEROPOSTERIOR, LATERAL, MORTISE Views), CT scan and other imaging modalities if necessary
- Investigations - routine and others
- Diagnosis - clinical and radiological
- METHOD OF TREATMENT – Conservative or surgical
- Surgical: External Fixator or definitive fixation - depending upon the size of swelling), Internal fixation will be done if required after swelling subsides.
- Surgical approach, nature of implant.
- Routine - antibiotics and analgesics / anti inflammatory drugs
- Post op evaluation - clinical examination and xray ankle (AP and Lateral view)

INCLUSION CRITERIA:

- Patients with posterior malleolus fracture - both open and closed injuries
- All patients18 years and above
- Patients willing to participapte in the study

EXCLUSION CRITERIA :

- Patients with pre-existing ankle arthritis
- Patients not willing to participate in the study.
- Patients with ankle arthrodesis
- Patient with pathological fracture

Data to be studied will include patient age and gender , mechanism of injury , date of injury, date of surgery, operative notes. The follow up will include details of mobilisation, weight bearing, complications and need for additional treatment. The minimum follow up period will be 6 months or completion of functional recovery after fracture union, whichever is later. Patients will be assessed at final follow up as per the AOFAS scoring system. Check radiographs consisting of standard antero posterior and lateral views will be taken at monthly intervals.

OUTCOME

The outcome at final follow up will be calculated using AOFAS scoring system

STATISTICAL ANALYSIS

Data will be described in terms of range; mean ±standard deviation (± SD), frequencies (number of cases) and relative frequencies (percentages) as appropriate. All statistical calculations will be done using SPSS (Statistical Package for the Social Science) SPSS 21 version statistical program for Microsoft Windows.

7.3 DOES THE STUDY REQUIRE ANY INVESTIGATIONS OR INTERVENTIONS TO BE CONDUCTED ON PATIENTS OR OTHER HUMANS OR ANIMALS? IF SO, PLEASE DESCRIBE BRIEFLY.

ROUTINE investigations

XRAYS, CT scan, further imaging if required.

7.4 HAS THE ETHICAL CLEARANCE BEEN OBTAINED FROM ETHICAL COMMITTEE OF YOUR INSTITUTION IN CASE OF 7.3?

Yes, attached herewith.

8. LIST OF REFERENCES

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PROFORMA

NAME		AGE/SEX	
MRD NO		ADMISSION NO	
FATHER'S NAME/HUSBAND NAME		OCCUPATION	
DATE OF ADMISSION		DATE OF INJURY	
DATE OF SURGERY		DATE OF DISCHARGE	

Mode of injury: RTA/ Fall/ Others

Type of fracture: Open / Closed

Associated illness /injury:

Classification of fracture:

1) Lauge Hansen

1. Supination Adduction (SA)
2. Supination - Eversion (External rotation) (SER)
3. Pronation Abduction (PA)
4. Pronation Eversion (External rotation) (PER)
5. Pronation Dorsiflexion (PD)

2) DANIS WEBER: Type A/B/C

3) Haraguchi: Type 1/2/3

4) AO/OTA Classification:

External Fixator: YES / NO Date of application:

DATE OF REMOVAL:

Fixation used for posterior malleolus: None/Plate/ Screw/ Other

Signature of candidate **Signature of Supervisor**

Approach used for posterior malleolus fixation:

Fixation for medial mallelolar fracture and approach:

Fixation for lateral mallelolar fracture and approach:

Immobilisation done: Yes/ No

Physiotherapy:

Range of motion _____ days/weeks Partial weight bearing _____ weeks

Full weight bearing _____ weeks

Complications :

1. Intra-operative: Nerve Palsy / Vascular injury / Loss of reduction / Any other
2. Immediate Post-operative: Wound infection - Superficial or Deep / Haemorrhage / Loss of reduction / Wound Dehiscence
3. Late Post-operative: Non-Union / Malunion / Subluxation / Ankle arthritis / Infection / Ankle stiffness / Any other

Findings on follow up :

Duration	X ray findings	Dorsi flexion at ankle joint	Plantar flexion at ankle joint
4 weeks			
8 weeks			
12 weeks			
16 weeks			
20 weeks			
24 weeks			
Others			

Union time

Clinical _____ weeks Radiological _____ weeks

FINAL AOFAS SCORE

Signature of candidate **Signature of Supervisor**

Ankle-Hindfoot Scale (100points Total)

PAIN (40 POINTS)	
NONE	40
MILD, OCCASIONAL	30
MODERATE, DALY	20
SEVERE, AL,OST ALWAYS PRESENT	0

FUNCTION(50 POINTS)	
ACTIVITY LIMITATIONS, SUPPORT REQUIREMENT	
NO LIMITATIONS, NO SUPPORT	10
NO LIMITATIONS OF DAILY ACTIVITIES, LIMITATIONS OF RECREATIONAL ACTIVITIES, NO SUPPORT	7
LIMITED DAILY AND RECREATIONAL ACTIVITIES, CANE	4
SEVERE LIMITATION OF DAILY AND RECREATIONAL ACTIVITY, WALKER, CRUTCHES, WHEEL CHAIR, BRACE	0

Signature of candidate **Signature of Supervisor**

MAXIMUM WALKING DISTANCE, BLOCKS	
GREATER THAN 6	5
4-6	4
1-3	2
LESS THAN 1	0

WALKING SURFACES	
NO DIFFICULTY ON ANY SURFACE	5
SOME DIFFICULTY ON UNEVEN TERRAIN, STAIRS, INCLINES, LADDERS	3
SEVERE DIFFICULTY ON UNEVEN TERRAIN, STAIRS, INCLINES, LADDERS	0

GAIT ABNORMALITY	
NONE, SLIGHT	8
OBVIOUS	4
MARKED	0

Signature of candidate **Signature of Supervisor**

SAGGITALMOTION (FLEXION PLUS EXTENSION)	
NORMAL OR MILD RESTRICTION (30 DEGREE OR MORE)	8
MODERATE RESTRICTION(15 -29 DEGREE)	4
SEVERE RESTRICTION (LESS THAN 15)	0

HIND FOOT MOTION (INVERSION PLUS EVERSION)	
NORMAL OR MILD RESTRICTION (75-100 % NORMAL)	6
MODERATE RESTRICTION (25-74 % NORMAL)	3
MARKED RESTRICTION(LESS THAN 25 % NORMAL)	0

ANKLE HINDFOOT STABILITY(ANTEROPOSTERIOR, VARUS-VALGUS)	
STABLE	8
DEFINITELY UNSTABLE	0

ALIGNMENT(10 POINTS)	
GOOD, PLANTIGRADE FOOT , MIDFOOT WELL ALIGNED	15
FAIR , PLANTIGRADE FOOT, SOME DEGREE OF MIDFOOT MALALIGNMENT, OBSERVED, NO SYMPTOMS	8
POOR NON PLANTIGRADE FOOT, SEVERE MALALIGNMENT ,SYMPTOMS	0

Signature of candidate

Signature of Supervisor

INFORMED PATIENT CONSENT

Date: _____

I.....D/o, W/o, S/o.....

am willing to participate in the study **"FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS"** The procedure with its complications has been explained to me in local vernacular language. I have fully understood that no special tests and extra expenditure in any form, merely for the purpose of thesis is being carried out. I am free to opt out the study any time without assigning any reason.

.....
Signature of the Witness

Name:

.....
Signature of the patient

Signature of Candidate

Signature of Supervisor

मरीज अनुमति फार्म

तिथि _____

मैं _____ पत्नी/पुत्र/पुत्री _____ निवासी _____ इस शोधकार्य **"FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS"** में भाग लेने के लिए सहमत हूँ। मैं इस शोधकार्य में भाग लेने के लिए अपनी स्वेच्छा से तैयार हूँ। मैं पुष्टि करता/करती हूँ की यह स्वीकृति देने के लिए मुझे कोई आर्थिक प्रलोभन नहीं दिया गया और न ही दबाव डाला गया है। मुझे इस शोधकार्य का उद्देश्य स्पष्ट कर दिया गया है और मुझे यह विश्वास है की यह विज्ञान और मानवता के लाभ के लिए है। मुझे इस शोधकार्य में होने वाले जोखिम के बारे में समझा दिया गया है और मेरी समझ में यह जोखिम बहुत मामुली है।

मैं इस शोधकार्य में भाग लेने के सम्बन्ध में किसी भी समय अपनी अस्वीकृति व्यक्त कर सकता/सकती हूँ और मेरे अस्वीकृति व्यक्त करने का मेरे इलाज पर कोई प्रभाव नहीं पड़ेगा।

_____
गवाह के हस्ताक्षर
नाम:

_____
रोगी के हस्ताक्षर/अंगूठे का निशान
नाम:

_____
अन्वेषक के हस्ताक्षर

_____
विद्यार्थी के हस्ताक्षर

ਮਰੀਜ਼ ਰਜ਼ਾਮੰਦੀ ਫਾਰਮ

ਮਿਤੀ_____

ਮੈ_____ਪਤਨੀ/ਪੁੱਤਰ/ਪੁੱਤਰੀ_____

ਵਾਸੀ _____

"FUNCTIONAL OUTCOME OF ANKLE FRACTURES ASSOCIATED WITH FRACTURE OF POSTERIOR MALLEOLUS" ਤੇ ਚਲ ਰਹੀ ਖੋਜ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਰਜ਼ਾਮੰਦ ਹਾਂ। ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਲਈ ਮੈ ਆਪਣੀ ਮਰਜ਼ੀ ਨਾਲ ਤਿਆਰ ਹਾਂ। ਮੈ ਇਹ ਦਸਣਾ ਚਾਹੁੰਦਾ ਹਾਂ/ ਚਾਹੁੰਦੀ ਹਾਂ ਕੇ ਇਹ ਰਜ਼ਾਮੰਦੀ ਦੇਣ ਵਾਸਤੇ ਮੈਨੂ ਕਿਸੇ ਵੀ ਤਰਾਂ ਦਾ ਲੋਭ-ਲਾਲਚ ਨਹੀ ਦਿੱਤਾ ਗਿਆ ਅਤੇ ਨਾ ਹੀ ਕੋਈ ਦਬਾ ਪਾਇਆ ਗਿਆ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਦਾ ਮਨੋਰਥ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਭਰੋਸਾ ਦਵਾਇਆ ਗਿਆ ਹੈ ਕੇ ਇਹ ਖੋਜ ਵਿਗਿਆਨ ਅਤੇ ਮਾਨਵਤਾ ਦੀ ਭਲਾਈ ਲਈ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਵਿਚ ਹੋਣ ਵਾਲੇ ਖਤਰੇ ਬਾਰੇ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ ਅਤੇ ਮੈਨੂ ਇਹ ਯਕੀਨ ਹੈ ਕੇ ਇਹ ਖਤਰਾ ਬਹੁਤ ਮਾਮੂਲੀ ਹੈ। ਮੈਨੂ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਦਾ ਢੰਗ – ਤਰੀਕਾ ਸਮਝਾ ਦਿੱਤਾ ਗਿਆ ਹੈ।

ਮੈ ਇਸ ਖੋਜ ਕੰਮ ਵਿਚ ਹਿੱਸਾ ਲੈਣ ਬਾਰੇ ਆਪਣੀ ਰਜ਼ਾਮੰਦੀ ਕਿਸੇ ਵੀ ਸਮੇ ਵਾਪਸ ਲੈ ਸਕਦਾ ਹਾਂ/ ਸਕਦੀ ਹਾਂ ਅਤੇ ਮੇਰੀ ਰਜ਼ਾਮੰਦੀ ਵਾਪਸ ਲੈਣ ਦਾ ਮੇਰੇ ਇਲਾਜ ਤੇ ਕੋਈ ਅਸਰ ਨਹੀ ਹੋਵੇਗਾ।

_____ _____

ਗਵਾਹ ਦੇ ਹਸਤਾਖਰ ਮਰੀਜ਼ ਦੇ ਹਸਤਾਖਰ

ਮਿਤੀ_____ ਮਿਤੀ_____

ਪਤਾ _____ ਪਤਾ _____

_____

ਨਿਰੀਖਕ ਦੇ ਹਸਤਾਖਰ

_____

ਸਿਖਿਆਰਥੀ ਦੇ ਹਸਤਾਖਰ